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The New England Division (NED), U.S. Army Corps of Engineers performed major rehabilitation work on the Bourne Bridge, one of two highway spans over the Cape Cod Canal, during the years 1979 through 1981. Since sandblasting was carried out to prepare a proper surface for repairing and repainting, and some of the old paint to be removed from the bridge contained lead, an air quality monitoring program was instituted to ensure that no adverse effect on public health and welfare would result. Five air monitoring stations located in the vicinity of

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the bridge continuously monitored total suspended particulate (TSP) and lead concentrations for the 19 month period during which sandblasting took place.

Concentrations of lead and TSP were generally very low in comparison to the Federal and State air quality standards. During the entire monitoring program, there were no exceedances of the lead standards, annual TSP standards or the primary 24-hour TSP standard at any of the five monitoring stations. The secondary 24-hour TSP standard was exceeded 7 times on days of sandblasting. The highest concentrations of lead and particulate were recorded at the downwind sites closest to the sandblasting.

Additionally, a dustfall bucket network was operated for 14 months, to measure fallout of larger particles of lead and TSP. Two source strength sampling experiments were also conducted to obtain direct measurements of particle size distribution and source strength.

Prepared for

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AIR MONITORING AT THE BOURNE BRIDGE
CAPE COD CANAL, MASSACHUSETTS
30 OCTOBER 1979 THROUGH 31 MAY 1981

Final Report

January 1982

Prepared by

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CONTENTS

EXECUTIVE SUMMARY

BACKGROUND AND PROGRAM GOALS

The New England Division of the U.S. Army Corps of Engineers began rehabilitation work on the Bourne Bridge, one of two highway spans over the Cape Cod Canal, in the fall of 1979. In performing this type of work, sandblasting is carried out to prepare a proper surface for repairing and repainting. As a result of the introduction of sandblasting material and paint and rust into the atmosphere during this process, ambient concentrations of total suspended particulates (TSP) increase temporarily in the immediate vicinity of the sandblasting. Since some of the old paint to be removed from the bridge contained lead (Pb), an increase in the level of this material was also expected. To ensure that no adverse effect on public health and welfare would result from these activities, the Corps engaged GCA/Technology Division to design and install a monitoring network surrounding the bridge and operate it continuously during the period of rehabilitation. This report summarizes the Pb and particulate data collected from the start of the monitoring program on 30 October 1979 through 31 May 1981 when the rehabilitation had been completed.

The primary objective of the program was to ensure that Federal and State air quality standards for TSP and Pb were maintained in the vicinity of the bridge during its rehabilitation. This objective was met through the installation and maintenance of a continuous monitoring network. A supplementary network was installed to provide continuous particulate fallout data. A secondary objective was to collect data that would make it possible to express Pb and particulate emissions from bridge sandblasting activities in terms of a source strength. This second objective was fulfilled by conducting two sets of short-term experiments aimed at providing sandblasting particle size distribution information.

MONITORING PROGRAM

(1) Continuous Monitoring--Daily 24-hour observations of lead and TSP were made at five monitoring sites. Lead and TSP were measured by conventional high-volume air samplers (hi-vols) located in the vicinity of neighboring residential and recreational areas and areas of maximum impact.

(2) Particulate Fallout--Particulate fallout data were obtained monthly from nine dustfall buckets located along each side of the canal.

(3) Source-Strength Sampling--Two short-term experiments were conducted on the bridge to obtain direct measurements of particle size distribution and source strength.

(4) Supporting Measurements--A meteorological station at the Army Corps of Engineers Canal Administration building in nearby Buzzards Bay, Massachusetts, was expanded to provide additional meteorological data. Traffic volume information was provided by the State of Massachusetts Public Works Department.

FINDINGS

The predominant amount of particulate generated during sandblasting was sufficiently large in particle size to be strongly affected by gravitational settling. As a result, the highest concentrations of lead and particulate were recorded at the downwind sites closest to the sandblasting. These concentrations were generally very low in comparison to the Federal and State ambient air quality standards.

During the entire monitoring program, there were no exceedances of lead standards, annual TSP standards, or the primary 24-hour TSP standard at any of the five monitoring stations. The secondary 24-hour TSP standard was exceeded once at three of the sites; however, these were not violations of the standard, since one exceedance per site is permitted. The four other exceedances recorded during the project all occurred at Site 5. All seven exceedances were at locations downwind of the sandblasting. One additional exceedance was noted on a non-sandblasting day.

The greatest fallout of lead and particulate, as measured by the dust-fall bucket network and averaged over the 14-month collection period, occurred directly beneath the bridge on the north and south sides of the canal. The highest fallout rates for lead and particulate for any one month at a single site were 8.0 $g/m^2/mo$ and 10,159 $g/m^2/mo$, respectively.

The amount of lead and particulate introduced into the atmosphere by one sandblaster (source strength) was estimated to be 2.7 and 133 lb/hr, respectively, during the first experiment, and 4.2 and 345 lb/hr, respectively, during the second experiment. Of this particulate, 1.6 percent, containing 3 percent of the total lead, was found to be respirable (≤ 2.5 μm in diameter), and 10 percent, containing 16 percent of the total lead, was inhalable (≤ 15 μm in diameter).

FIGURES

TABLES

ACKNOWLEDGMENTS

SECTION 1

INTRODUCTION

BACKGROUND AND PROGRAM GOALS

The New England Division of the U.S. Army Corps of Engineers began rehabilitation work on the Bourne Bridge, one of two highway spans over the Cape Cod Canal, in the fall of 1979. In performing work of this type, sandblasting is carried out to prepare a proper surface for repairing and repainting. As a result of the introduction of sandblasting material and paint and rust into the atmosphere during this process, ambient concentrations of total suspended particulates (TSP) increase temporarily in the immediate vicinity of the sandblasting. Since some of the old paint to be removed from the bridge contained lead (Pb), an increase in the level of this material was also expected. Although these temporary increases in TSP and Pb were anticipated to have only minor impact on ambient concentrations, no field measurements were available that documented levels during similar bridge rehabilitation activities. To provide such information and to ensure that no adverse effect on public health and welfare would result from the rehabilitation, the Corps engaged GCA/Technology Division to design and install a monitoring network surrounding the bridge and operate it continuously during the period of bridge rehabilitation.

The primary objective of the program was to ensure that Federal and State ambient air quality standards for Pb and TSP were maintained in the vicinity of the bridge during its rehabilitation. The standards are the same on the Federal and State levels. A secondary objective was to collect data that would make it possible to express Pb and particulate emissions from bridge sandblasting activities in terms of a source strength—for example, the mass of material which is introduced into the atmosphere by one operator during one hour of sandblasting. Expressed in this way, data obtained during the monitoring program could be more easily used to plan environmentally safe sandblasting operations during other similar bridge rehabilitation work.

SCOPE AND ORGANIZATION OF REPORT

The principal purpose of this report is to summarize the Pb and particulate data collected during the 19-month monitoring program, which was conducted from 30 October 1979 through 31 May 1981. The report also includes supplementary information necessary for the proper interpretation of the data.

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The organization of the remainder of the report is as follows. Section 2 describes the design and operation of the monitoring program, Section 3 summarizes the field observations, and Section 4 presents the principal findings of the study. Appendix A describes the equipment and methodology used in the source-strength measurements; Appendix B presents the analytical procedures used by the laboratory in carrying out the Pb analyses and documents the quality control procedures for these analyses; Appendix C discusses the influence of gravitational settling and atmospheric dispersion on the distribution of sandblasting material; and Appendix D presents the particle fallout data.

SECTION 2

DESIGN AND OPERATION OF THE MONITORING PROGRAM

The monitoring program consisted of the operation of networks providing continuous particulate and fallout data, and the collection of two sets of short-term measurements to provide source strength information. Meteorological data necessary for the interpretation of the measurements were recorded continuously at the nearby Army Corps of Engineers Canal Administration Building located in Buzzards Bay. The various parts of the monitoring program are described in the remainder of this section.

MONITORING FOR SUSPENDED PARTICULATES AND LEAD

Sampling Method

The reference method for measuring suspended particulates in the atmosphere is called the high-volume method.[1] It consists of collecting particulates from a known volume of air on a glass fiber filter for subsequent weighing. Concentrations are reported in micrograms of particulate per standard cubic meter of air ($\mu g/m^3$). The measurements are made with a high-volume sampler (hi-vol) operated for 24 hours--normally midnight to midnight--and sampling is initiated and terminated by use of timers. Each of the sites in the network was equipped with two samplers in order that continuous 24-hour samples could be collected throughout the program utilizing the timer activation approach.

The reference method for determining the concentration of lead in suspended particulate matter is a nitric acid extraction method performed on a portion of the exposed hi-vol filter.[2] All of the hi-vol filters were analyzed for lead, and the lead concentrations were expressed as $\mu g/m^3$.

Design of the Hi-Vol Network

The basic plan specified the operation of 5 hi-vols at fixed locations for the duration of the program. Insofar as possible, the samplers were to monitor concentrations in neighboring residential and recreational areas and areas of maximum impact. As a first step in the design of the network, the orientation of the bridge with respect to prevailing winds was examined. Figure 1 shows the bridge and surrounding topographic features plus seasonal wind direction roses. Southwesterly winds are predominant during the summer, while winds from the west to northwest predominate during the winter. Northeasterly winds are frequently associated with rain or snow.

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Figure 1. Bourne Bridge and surrounding topographical features, and seasonal wind direction roses. The length of the barb shows the percent of time the wind blew from the indicated direction.

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Other factors that were considered when designing the network included:

- height of sandblasting (particle release height)

- terminal velocities of particles

- transport wind speeds, and

- typical atmospheric stability conditions.

Areas likely to experience the greatest impact from sandblasting were determined by using suitable values of these parameters to calculate probable directions and distances likely to be traveled by the particles. Consideration of the results led to the network shown in Figure 2. Site 1, on the south side of the Canal and 112 meters west of the bridge, was located to monitor the impact on the adjacent residential area as well as to provide background observations during periods with westerly winds. Site 2, on the south side of the Canal and 200 meters east of the bridge, was designed to monitor the maximum effects of the construction activity on the south end of the bridge during light southwesterly winds. In addition, it would also be downwind of sandblasting conducted on the centerspan of the bridge during northwesterly winds.

Site 3, also on the south side of the canal, was located approximately 450 meters east of the bridge. This site should be most affected during moderate to strong southwesterly winds with sandblasting activity on the south end of the bridge and during moderate to strong west to northwesterly winds with sandblasting on the centerspan or north end of the bridge.

Site 4, on the north side of the canal and 275 meters east of the bridge, was located downwind of the middle of the bridge during the prevailing southwesterly winds. It was also adjacent to the Bourne Scenic Park, a popular camping area, and was therefore expected to provide useful data indicative of the lead and TSP exposure on the periphery of the Park. Site 5 was within the Bourne Scenic Park approximately 125 meters from the bridge and downwind of sandblasting on the northern half of the centerspan during southwesterly winds. It was also downwind of the north section of the bridge during west to northwest winds. Site 5 was brought into the daily operation on 20 April 1980.

A view of monitoring sites 2 and 3, taken toward the northwest and west, respectively, is presented in Figure 3. The pair of hi-vol shelters (and dustfall bucket) at each site can be seen in the figure. All hi-vols were mounted on poles, with the sampler inlets being 3.5 meters above ground level. A side view of Bourne Bridge numerically calling out spans and bays is presented in Figure 4. A span encompasses the distance between concrete pilings. A bay encompasses the distance between vertical truss members inside a span.

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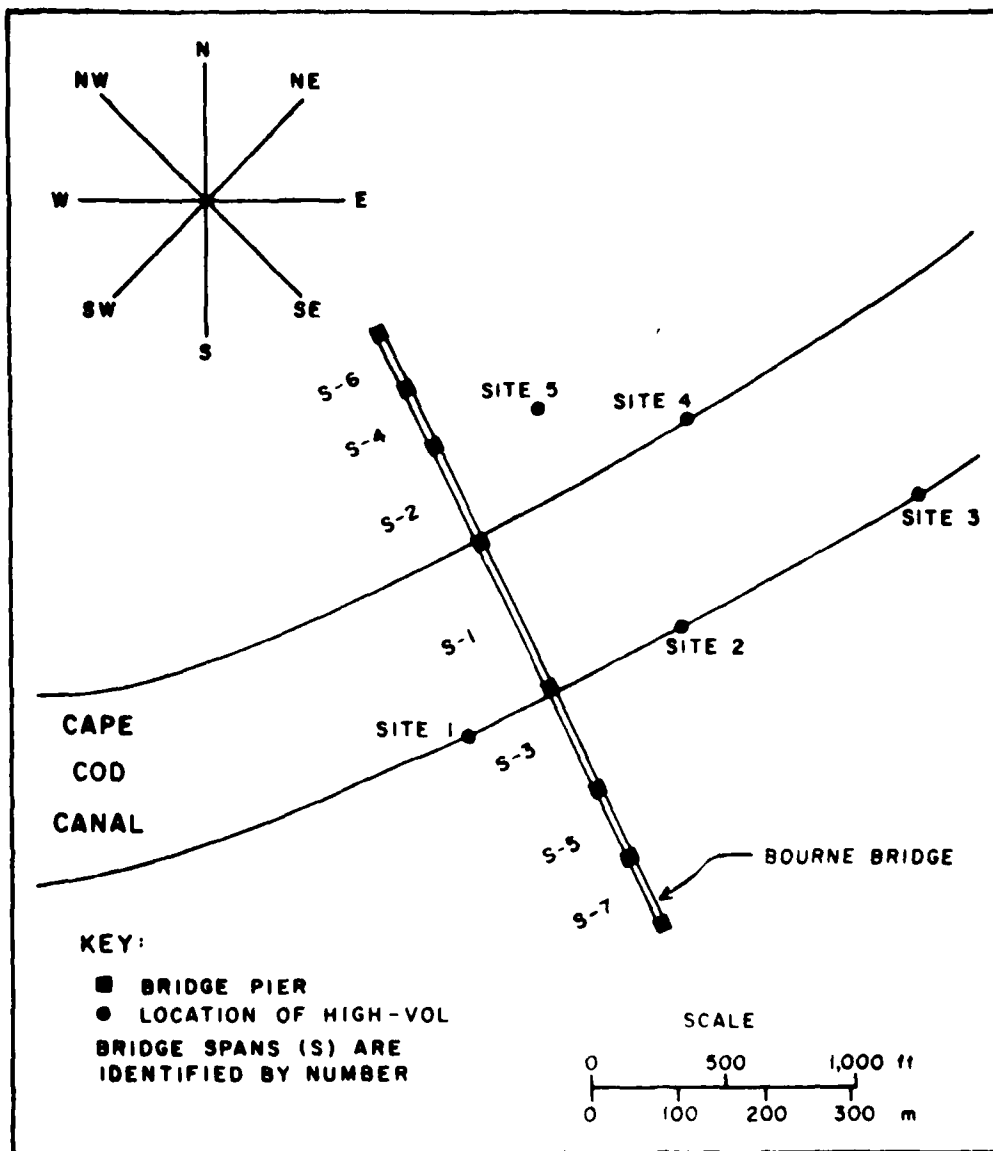
Figure 2. Hi-vol network in the vicinity of Bourne Bridge.

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Monitoring Site 3

Monitoring Site 2

Figure 3. Monitoring Sites 2 and 3 at Bourne Bridge.

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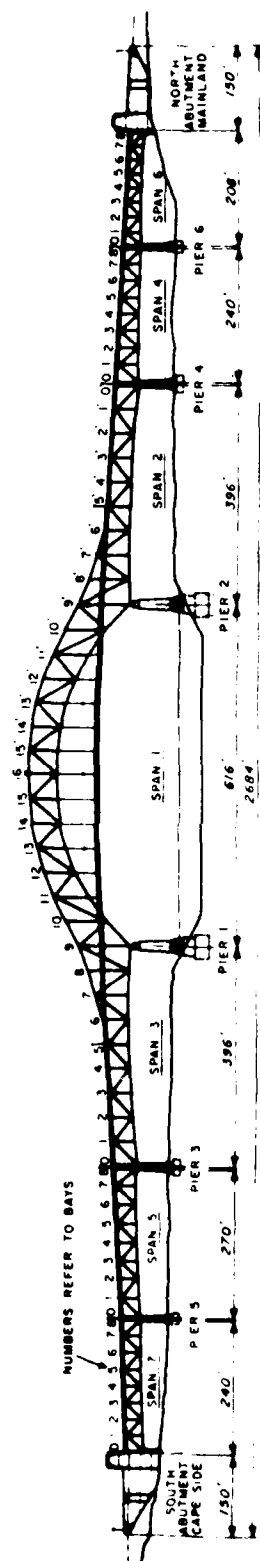
Figure 4. Bourne Bridge showing spans and bays.

PARTICLE FALLOUT MONITORING

Sampling Methodology

Particle fallout is measured by exposing an open container of known cross-section for a specific period of time (usually about one month). The collected material is then weighed and, if desired, analyzed. In this project, the contents of the fallout buckets were analyzed for lead. Results were reported in units of mass per unit area per unit time (e.g., $g/m^2/mo.$).

Network Design

The intent was to select monitoring locations such that the deposition rate of large particles generated by the rehabilitation of the bridge could be estimated by comparing the fallout near the bridge with values from predominantly upwind locations, or from sites well removed from the bridge.

Consideration of the factors previously used in the design of the hi-vol network led to the dustfall network shown in Figure 5. On 5 and 6 December 1979, nine buckets were installed on poles along each side of the canal and placed predominantly on the east side of the bridge. The buckets were spaced more closely together near the bridge where the highest fallout levels were expected in an effort to define the area of maximum impact. Operation of the particle fallout network was terminated February 3, 1981.

SOURCE STRENGTH EXPERIMENTS

Sampling equipment was operated on the bridge immediately downwind from the sandblasting in an attempt to obtain direct measurements of particle size distribution and source strength. Air was sampled as it exited the bay in which sandblasting was taking place. The average concentration of particulates in the exiting air (less a small background concentration), multiplied by the total volume of air passing through the bay during the sampling period, was assumed to equal the amount of material introduced into the ambient air by sandblasting in the bay. The success of these experiments depended in large part upon how well the average concentration could be approximated by point measurements.

Two sets of measurements were conducted. In the first, conducted on 2 and 3 April 1980, a regular hi-vol with a restricted orifice and a cyclone equipped hi-vol using a Sierra Instruments Model 230 CP Cyclone Preseparator were operated side-by-side in Span 7. In the second sampling program, conducted on 21 and 22 October 1980, two Inhalable Particulate Cyclone Samplers, spaced approximately 8 feet apart, were operated simultaneously in Span 6. A view of the installed sampling equipment for each program is presented in Figure 6. Appendix A presents a detailed account of the two experiments, including the particle size intervals measured by the equipment.

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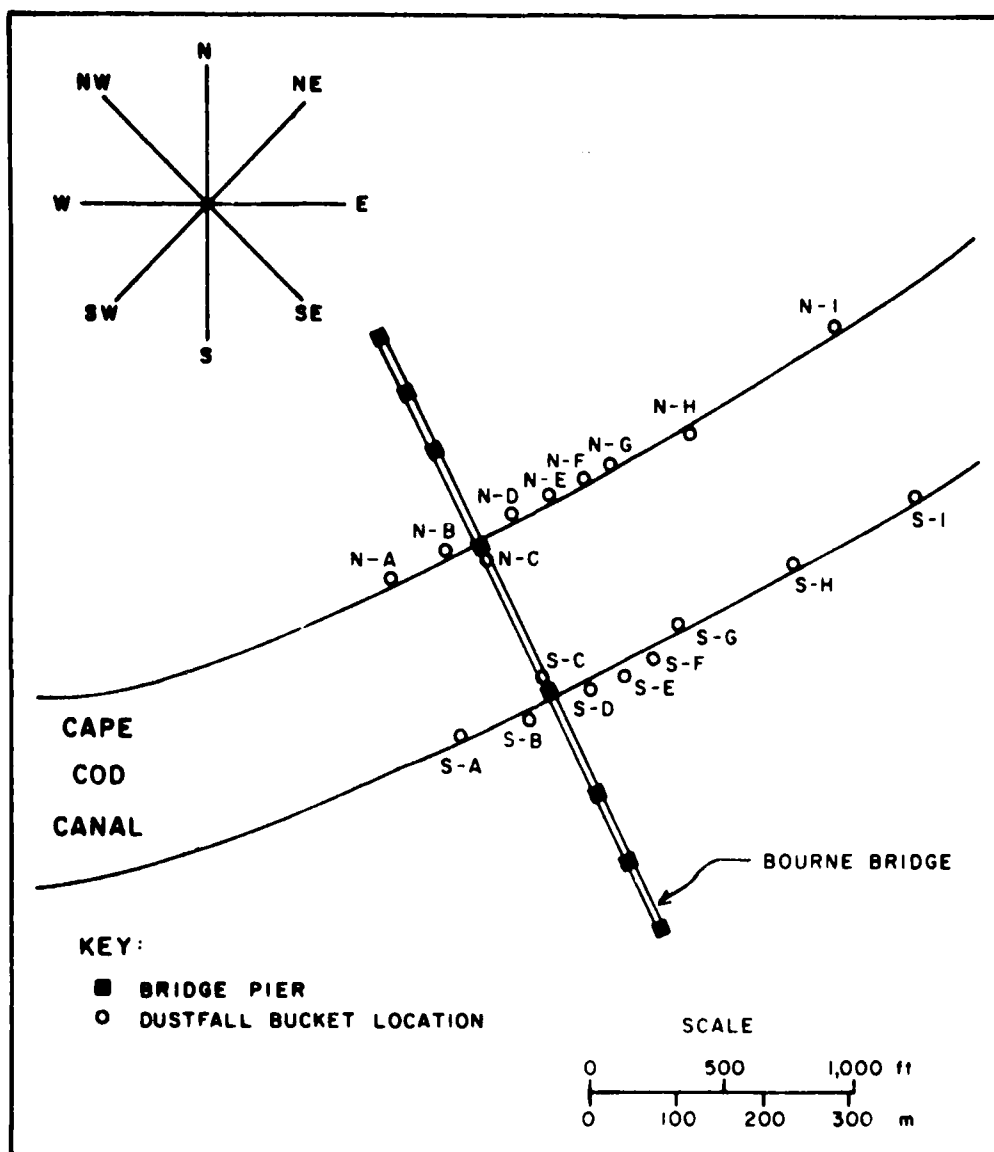
Figure 5. Dustfall bucket network in the vicinity of
Bourne Bridge.

First sampling program, April 2 and 3, 1980.

Second sampling program, October 21 and 22, 1980.

Figure 6.   Source strength sampling equipment.

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METEOROLOGICAL DATA RECORDING

Wind speed, wind direction, and general weather conditions were logged by the Corps of Engineers at the Canal Administration Building approximately 1-1/2 miles west of the Bourne Bridge located in Buzzards Bay. Arrangements to record the wind data continuously were completed on 23 January 1980. In addition, precipitation and temperature recorders were installed at the same location on 5 February 1980.

TRAFFIC DATA COLLECTION

Ambient concentrations of Pb and TSP both increase in the immediate vicinity of well traveled roadways as a result of automobile tailpipe emissions and the reentrainment of road dust.[3] It was therefore felt that the changes in traffic patterns and volume that would occur during the course of bridge rehabilitation might have a noticeable impact on air quality at the nearest monitoring sites. Vehicle counts conducted on a routine but somewhat intermittent basis at the south end of the bridge by the Commonwealth of Massachusetts were made available to this project. Data for the period from November 1979 through August 1980 are included in this report.

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SECTION 3

FIELD OBSERVATIONS

TWENTY-FOUR HOUR AVERAGE CONCENTRATIONS OF LEAD AND SUSPENDED PARTICULATES

The ambient air quality surrounding the Bourne Bridge was monitored
continuously during the period of 30 October 1979 through 31 May 1981, and the
results were compared to the Federal and State primary and secondary
standards. The primary and secondary standards define levels of air quality
which will protect the public's health and welfare, respectively, and are as
follows:[4]

- Pb, primary and secondary standards
  (a) 1.5 $\mu g/m^3$--calendar quarter arithmetic mean

- TSP, primary standard
  (a) 75 $\mu g/m^3$--annual geometric mean
  (b) 260 $\mu g/m^3$--maximum 24-hour concentration not to be exceeded
       more than once per year.

  TSP, secondary standard
  (a) 60 $\mu g/m^3$--annual geometric mean.
  (b) 150 $\mu g/m^3$--maximum 24-hour concentration not to be exceeded
       more than once per year.

Pb Concentrations

There were no exceedances of the Pb standards within the monitoring
network throughout the duration of the project. Table 1 presents the summary
Pb statistics for the five sites. The two highest average Pb concentrations
shown in the table are 0.17 $\mu g/m^3$ and 0.16 $\mu g/m^3$ reported at Sites 2 and
5, respectively, during the Fall '80 quarter. These concentrations are
approximately one-ninth of the 3-month standard. The Fall '80 quarter
recorded the highest concentrations of Pb at all sites, probably due to the
increased amount of sandblasting activity which occurred. An increase in Pb
concentration relative to other sites within the network was reported at
Site 5 during the Summer '80 quarter at 0.14 $\mu g/m^3$. This is probably due to
increased sandblasting impact during September, evidenced by the catches of
0.91 and 0.94 $\mu g/m^3$ Pb on the 17th and 23rd of that month. The lowest Pb
concentrations were observed during the Winter '80 quarter when construction
and traffic activity were both at a minimum. The average

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TABLE 1. SUMMARY STATISTICS OF Pb CONCENTRATIONS

Site	Number of observations[a]	% data capture	Arithmetic mean calendar quarter Pb concentrations, $\mu g/m^3$ [b]						
			Fall '79	Winter '80	Spring '80	Summer '80	Fall '80	Winter '81	Spring '81
1	557	96	(0.08)	0.04	0.10	0.09	0.15	0.12	(0.08)
2	543	94	(0.10)	0.06	0.12	0.11	0.17	0.13	(0.10)
3	544	94	(0.07)	0.06	0.13	0.09	0.15	0.11	(0.08)
4	554	96	(0.09)	0.05	0.10	0.09	0.14	0.09	(0.09)
5	366	90	NA	NA	(0.10)	0.14	0.16	0.11	(0.12)

[a]Total observations possible for Sites 1-4 and Site 5 are 580 and 407, respectively.

[b]Fall '79 data covered the period 10/30/79-12/31/79. Spring '80 data at Site 5 covered the period 4/20/80-6/30/80. Spring '81 data covered the period 4/1/81-5/31/81.

NA - calculations not available.

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lead content of the particulate collected by the hi-vols was 0.37 percent.
The data capture rate was 90 percent or greater at each site.

Individual site frequency distributions for 24-hour Pb concentrations are presented in Table 2. Slightly elevated 24-hour lead concentrations, arbitrarily defined as those equal to or greater than 0.50 µg/m^3, occurred on 22 days as shown in the table. Twenty of these 22 observations occurred on days with sandblasting activity and at sites downwind from that activity. (The two other observations were recorded in June and August when traffic volume was high, presumably due to seasonal vacationing activity.) Fifteen of the 20 elevated Pb concentrations occurred at the downwind sites closest to the sandblasting activity. These observations occurred at Sites 2 and 5, with 7 and 8 observations, respectively.

TSP Concentrations

Table 3 presents the summary statistics for TSP at the five sites throughout the duration of the project. There were no exceedances of the annual standards at any site and Site 5 recorded the highest mean concentration. Because this project spanned parts of three calendar years--1979, 1980 and 1981, with 1980 being the only complete year--an effort was made to include all the data for calculating the annual geometric means. Three years were defined: Year 2 represents the complete year 1980; Year 1 contains the 1979 data spliced into Year 2; Year 3 contains the 1981 data spliced into year 2. The high concentrations at Site 5 for Years 1 and 2 do not represent complete annual means. Year 3 has the highest complete annual mean of 33 µg/m^3 recorded at Sites 2 and 5. This annual mean is approximately one half of the annual secondary standard which is 60 µg/m^3. Site 1 consistently recorded the lowest annual mean.

There were no exceedances of the primary 24-hour standard during the program. Seven exceedances of the secondary 24-hour standard did occur at sites that were downwind from ongoing sandblasting activity. These exceedances occurred at the sites and on the days listed below:

- Site 2, 9 November 1979, 232 µg/m^3

- Site 3, 30 May 1980, 166 µg/m^3

- Site 5, 17 September 1980, 157 µg/m^3

- Site 5, 23 September 1980, 190 µg/m^3

- Site 5, 21 October 1980, 195 µg/m^3

- Site 4, 31 October 1980, 161 µg/m^3

- Site 5, 31 October 1980, 189 µg/m^3

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TABLE 2.   FREQUENCY DISTRIBUTIONS OF 24-HOUR Pb CONCENTRATIONS

Class interval $\mu g/m^3$	Number of observations				
	Site 1	Site 2	Site 3	Site 4	Site 5[a]
1.00-1.09	-	1	-	-	-
0.90-0.99	-	-	-	1	2
0.80-0.89	-	-	-	-	1
0.70-0.79	1	-	-	1	-
0.60-0.69	-	2	-	1	4
0.50-0.59[b]	2	4	1	-	1
0.40-0.49	5	9	5	2	3
0.30-0.39	13	12	12	7	11
0.20-0.29	40	51	57	35	40
0.10-0.19	138	148	147	152	128
0-0.09	358	316	322	355	176

[a]The monitoring period for Site 5 began on 20 April 1980.

[b]Concentrations $\geq$ 0.50 $\mu g/m^3$ are arbitrarily defined herein as "elevated catches of Pb."

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TABLE 3. SUMMARY STATISTICS OF 24-HOUR TSP CONCENTRATIONS

| | | | Exceedances of the 24-hour TSP standards | | Annual TSP geometric mean concentration, $\mu g/m^3$ | | |
Site	Number of observations[a]	% data capture	Primary	Secondary	Year 1[b]	Year 2[c]	Year 3[d]
1	551	95	0	0	21	22	28
2	534	92	0	1	23	23	33
3	537	93	0	1	22	23	29
4	548	94	0	1	25	25	30
5	366	90	0	4	(37)	(34)	33

[a]Total observations possible for Sites 1-4 and Site 5 is, 580 and 407, respectively.

[b]For Sites 1, 2, 3 and 4, the mean covers the 12-month period 11/1/79-10/31/80. For Site 5, the mean covers the period 4/20/80-10/31/80.

[c]For Sites 1, 2, 3 and 4, the mean covers the 12-month period 1/1/80-12/31/80. For Site 5, the mean covers the period 4/20/80-12/31/80.

[d]For Sites 1, 2, 3, 4 and 5, the mean covers the 12-month period 6/1/80-5/31/81. The annual geometric mean concentration for Site 5 covering the period 4/20/80-4/19/81 is 32 $\mu g/m^3$.

Sites 2 and 5 were the closest downwind sites to the sandblasting activity on
5 of these 7 days. On 30 May 1980, Site 2 was a closer downwind site but
concentrations were not measured at this location due to equipment
malfunction. The exceedance that was observed at Site 3 on this date
presumably resulted from a combination of sandblasting and heavy 4-lane summer
traffic. The exceedances at Sites 4 and 5 on 31 October 1980 are probably a
reflection of heavy sandblasting activity. In addition, the secondary
standard was equalled on a day on which sandblasting did not take place: 23
May 1981, Site 4, 150 µg/m^3. Frequency distributions of the 24-hour TSP
concentrations are presented by site in Table 4.

Seasonal Variations in Pb and TSP Concentrations

Lead and TSP concentrations at the various monitoring locations can be
affected by seasonal variations in wind direction, traffic volume, and the
amount of sandblasting. However, relationships between emissions and measured
concentrations are complicated by changes in the geometric configuration of
sources and receptors and in restrictions of traffic flow necessitated by the
bridge rehabilitation. A rough indication of seasonal changes in the
principal locations of sandblasting throughout the project is given by Table
5. Sandblasting began at the southern end of the bridge (Spans 3, 5, and 7)
and continued intermittently on these spans through July 1980. During March,
April and May, sandblasting also took place frequently on the principal bridge
span, No. 1. By September 1980, sandblasting was concentrated on the north
end of the bridge and the principal span. No sandblasting occurred in either
February or August. Of particular interest is the fact that sandblasting at
the north end of the bridge began in the fall of 1980, at the start of the
season when westerly and northwesterly winds become more frequent. As a
result, Site 5 was particularly well located to monitor any impact of the
bridge activities on air quality. Sandblasting continued predominantly on the
north end of the bridge for the duration of the project.

The bridge traffic volume was influenced by construction activities and
vacation travel. From September 1979 through late May 1980, three of the
four traffic lanes were closed because of construction. However, to
accommodate vacationing travelers, all four lanes were kept open from June
through August. From September 1980 through March 1981, three of the four
traffic lanes were again closed because of construction. During April and May
1981, successively more traffic lanes were reopened until all four lanes were
in use by late May. The effects of the traffic restrictions are shown in
Table 6 by noting the average daily traffic volume during prior years. The
latter set of numbers is based on 1976-1979 data. Because of gaps in the
data, the number of years included in each monthly average varies from 2 to
4. Table 6 shows that the average traffic volume during the summer of 1980
was more than three times as great as it had been during the months of traffic
restriction. Monthly traffic data during the construction activity ended in
August 1980.

Tables 7 and 8 present average Pb and TSP concentrations by season for
days with sandblasting (w) and for days without sandblasting (w/o). The Fall
'80 (w) season reports the highest concentration of Pb, presumably due to the

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TABLE 4.   FREQUENCY DISTRIBUTIONS OF 24-HOUR TSP CONCENTRATIONS

Class interval µg/m^3	Number of observations				
	Site 1	Site 2	Site 3	Site 4	Site 5[a]
230–239	–	1	–	–	–
220–229	–	–	–	–	–
210–219	–	–	–	–	–
200–209	–	–	–	–	–
190–199	–	–	–	–	2
180–189	–	–	–	–	1
170–179	–	–	–	–	–
160–169	–	–	1	1	–
150–159[b]	–	–	–	1	1
140–149	–	–	–	1	1
130–139	1	2	–	1	–
120–129	–	4	–	2	1
110–119	–	2	1	–	4
100–109	2	2	–	–	3
90–99	–	4	1	–	5
80–89	2	6	5	8	7
70–79	4	7	8	8	8
60–69	7	19	15	16	21
50–59	32	34	30	29	32
40–49	58	60	70	60	56
30–39	122	109	101	112	61
20–29	155	149	149	177	104
10–19	109	85	97	96	49
0–9	59	50	59	36	10

[a]The monitoring period for Site 5 began on 4/20/80.

[b]The secondary air quality standard is 150 µg/m^3.

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TABLE 5. FREQUENCY OF SANDBLASTING BY SPAN AND MONTH

| | | Number of days sandblasting occurred | | | | | | | |
| | | South side | | | Center | North side | | | |
Year	Month	S-7	S-5	S-3	S-1	S-2	S-4	S-6	Total
1979	Oct	--	-	1	-	-	-	-	1
	Nov	2	4	12	-	-	-	-	18
	Dec	11	7	1	-	-	-	-	19
1980	Jan	2	1	1	2	-	-	-	6
	Feb	-	-	-	-	-	-	-	0
	Mar	2	2	1	8	-	-	-	13
	Apr	11	10	-	12	-	-	-	33
	May	-	4	9	15	-	-	-	28
	June	3	8	5	-	-	..	-	16
	July	5	2	-	-	-	-	-	7
	Aug	-	-	-	-	-	-	-	0
	Sept	-	-	2	-	-	8	5	15
	Oct	-	-	4	5	16	5	2	32
	Nov	-	-	3	8	2	1	1	15
	Dec	-	-	-	-	-	1	4	5
1981	Jan	-	-	-	2	-	-	-	2
	Feb	-	-	2	2	-	-	-	4
	Mar	-	-	3	4	6	-	4	17
	Apr	-	-	5	7	3	1	1	17
	May	-	-	-	-	5	8	-	13
Total		36	38	49	65	32	24	17	

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TABLE 6. AVERAGE DAILY TRAFFIC VOLUME (ADT)
ACROSS THE BOURNE BRIDGE

Month	Normal volume[a]	Volume during rehabilitation (1979 - 1980)	Percent reduction
Nov.	17,685	6,317	64
Dec.	17,419	7,417	57
Jan.	16,774	6,227	63
Feb.	15,363	7,195	53
Mar.	18,218	7,176	61
Apr.	17,647	9,040	49
May	25,095	17,097	32
June	24,614	20,217	18
July	30,743	27,890	9
Aug.	31,488	27,484	13
Sept.	22,116	--	--
Oct.	23,285	--	--

[a]Based on 1976-1979 data, except 1976-1978 for Nov. and Dec.

TABLE 7. SEASONAL VARIATION IN Pb CONCENTRATION, DAYS WITH SANDBLASTING (W) VERSUS DAYS WITHOUT SANDBLASTING (W/O)

Arithmetic Mean concentration, $\mu g/m^3$

Site	Fall '79 (O-N, '79)		Winter '80 (D, '79; J-F, '80)		Spring '80[a] (M-A-M, '80)		Summer '80 (J-J-A, '80)		Fall '80 (S-O-N, '80)		Winter '81 (D, '80; J-F, '81)		Spring '81 (M-A-M; '81)	
	W	W/O	W	W/O	W	W/O	W	W/O	W	W/O	W	W/O	W	W/O
1	0.09 (15)	0.09 (17)	0.06 (19)	0.05 (72)	0.11 (40)	0.05 (40)	0.09 (19)	0.09 (70)	0.15 (44)	0.10 (39)	0.13 (11)	0.14 (79)	0.10 (45)	0.06 (47)
2	0.17 (15)	0.08 (17)	0.08 (19)	0.07 (71)	0.07 (39)	0.06 (38)	0.19 (20)	0.12 (69)	0.20 (45)	0.11 (34)	0.13 (10)	0.14 (75)	0.13 (44)	0.08 (47)
3	0.10 (15)	0.07 (16)	0.07 (19)	0.06 (71)	0.11 (38)	0.07 (39)	0.15 (19)	0.11 (69)	0.17 (44)	0.09 (37)	0.12 (11)	0.13 (78)	0.10 (45)	0.06 (43)
4	0.10 (15)	0.09 (17)	0.06 (19)	0.07 (71)	0.08 (40)	0.06 (37)	0.08 (19)	0.09 (69)	0.17 (48)	0.08 (40)	0.10 (11)	0.10 (77)	0.11 (44)	0.06 (47)
5	NA	NA	NA	NA	0.10 (18)	0.10 (12)	0.09 (20)	0.11 (70)	0.26 (48)	0.10 (40)	0.11 (11)	0.11 (75)	0.14 (31)	0.11 (41)

[a]For Site 5, the mean covers the period 4/20/80-5/31/80.

NA - Calculations not available.

Values within parentheses state number of observations.

TABLE 8. SEASONAL VARIATION IN TSP CONCENTRATION, DAYS WITH SANDBLASTING (W) VERSUS DAYS WITHOUT SANDBLASTING (W/O)

Arithmetic Mean concentration, $\mu g/m^3$

Site	Fall '79 (O-N, '79)		Winter '80 (D, '79; J-F, '80)		Spring '80[a] (M-A-M, '80)		Summer '80 (J-J-A, '80)		Fall '80 (S-O-N, '80)		Winter '81 (D, '80; J-F, '81)		Spring '81 (M-A-M, '81)	
	W	W/O	W	W/O	W	W/O	W	W/O	W	W/O	W	W/O	W	W/O
1	28 (14)	29 (14)	19 (19)	18 (72)	30 (40)	21 (40)	35 (19)	36 (70)	29 (44)	25 (39)	31 (11)	30 (79)	36 (45)	30 (45)
2	70 (13)	27 (13)	28 (19)	25 (70)	21 (39)	20 (38)	50 (20)	40 (69)	37 (45)	28 (34)	33 (10)	32 (75)	43 (44)	33 (45)
3	36 (13)	27 (13)	21 (19)	19 (71)	30 (38)	25 (39)	38 (19)	37 (69)	33 (44)	26 (37)	32 (11)	31 (78)	39 (45)	28 (41)
4	36 (12)	27 (16)	30 (19)	25 (71)	29 (40)	20 (37)	35 (19)	41 (69)	38 (48)	24 (40)	30 (11)	28 (77)	41 (44)	36 (45)
5	NA	NA	NA	NA	36 (18)	41 (12)	38 (20)	46 (70)	57 (48)	26 (40)	30 (11)	28 (75)	48 (31)	42 (40)

[a]For Site 5, the mean covers the period 4/20/80-5/31/80.

NA - Calculations not available.

Values within parentheses state number of observations.

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increased sandblasting during this period. On the whole, days with
sandblasting (w) show slightly higher concentrations of Pb than days without
sandblasting (w/o). The Spring '81 (w) season shows the highest TSP
concentration which is presumably due to sandblasting impact and increased
vehicular traffic. The second highest TSP concentration occurred during the
Summer '80 (w/o) season, and is probably a result of increased reentrained
dust and suspended particulates caused by heavy vacation traffic. Due to the
short duration of the monitoring period, the concentration at Site 2, Fall '79
(w) is not considered indicative of that season. The Winter '80 season saw
the uniformly lowest Pb and TSP concentrations, probably attributable to
reduced sandblasting and vehicular traffic across the bridge. On the whole,
days with sandblasting (w) show higher catches of TSP than days without
sandblasting (w/o), with the exception of the Summer '80 season.

PARTICLE FALLOUT DATA

Figures 7 and 8 show average horizontal profiles of lead and total
particulate fallout along the south and north sides of the canal,
respectively, for the period, 6 December 1979 through 3 February 1981. The
most pronounced feature of these curves is the occurrence of the greatest
fallout of both lead and total particulates directly beneath the bridge and
the consequent similarity of the profiles. This indicates that activities on
the bridge are primarily responsible for the fallout of both substances and
that the entrained and airborne particles are strongly affected by
gravitational settling. Asymmetry about the bridge is presumably a reflection
of the prevailing westerly winds at this locale (see Figure 1). During days
with sandblasting, the cross-bridge component of the wind was from the west
approximately 60 percent of the time, and from the east approximately 30
percent of the time. During the remaining 10 percent of the time, the wind
direction was generally parallel to the bridge. On the north side of the
bridge both the total particulate and lead profiles show a minimum in
concentration at Site E. This minimum arises principally as a result of
having no data at Site E for October 1980, the month with the greatest number
of days of sandblasting and the heaviest overall particulate fallout. Details
of the profiles for individual months are shown in Tables D-1 and D-2
(Appendix D).

The highest average rate of lead fallout measured by the network over the
14-month period at a single site was 1.3 g/m^2/month, and the highest rate
observed during any single month was 8.0 g/m^2/month in November 1980. Both
values occurred at Site C on the north side of the canal. The highest rate of
total particulate fallout averaged over the entire period occurred at Site C,
north of the canal, and was 939 g/m^2/month. The highest particulate fallout
rate observed during any single month was 10,159 g/m^2/month. This value was
measured at Site D on the north side of the canal, in October 1980. The lead
and particulate fallout was heaviest on the north side of the canal, with the
highest north side value at each site being approximately twice the
corresponding south side value.

Figures 9 and 10 contrast average lead and particulate concentrations
along the two sides of the canal during months with no sandblasting (February,
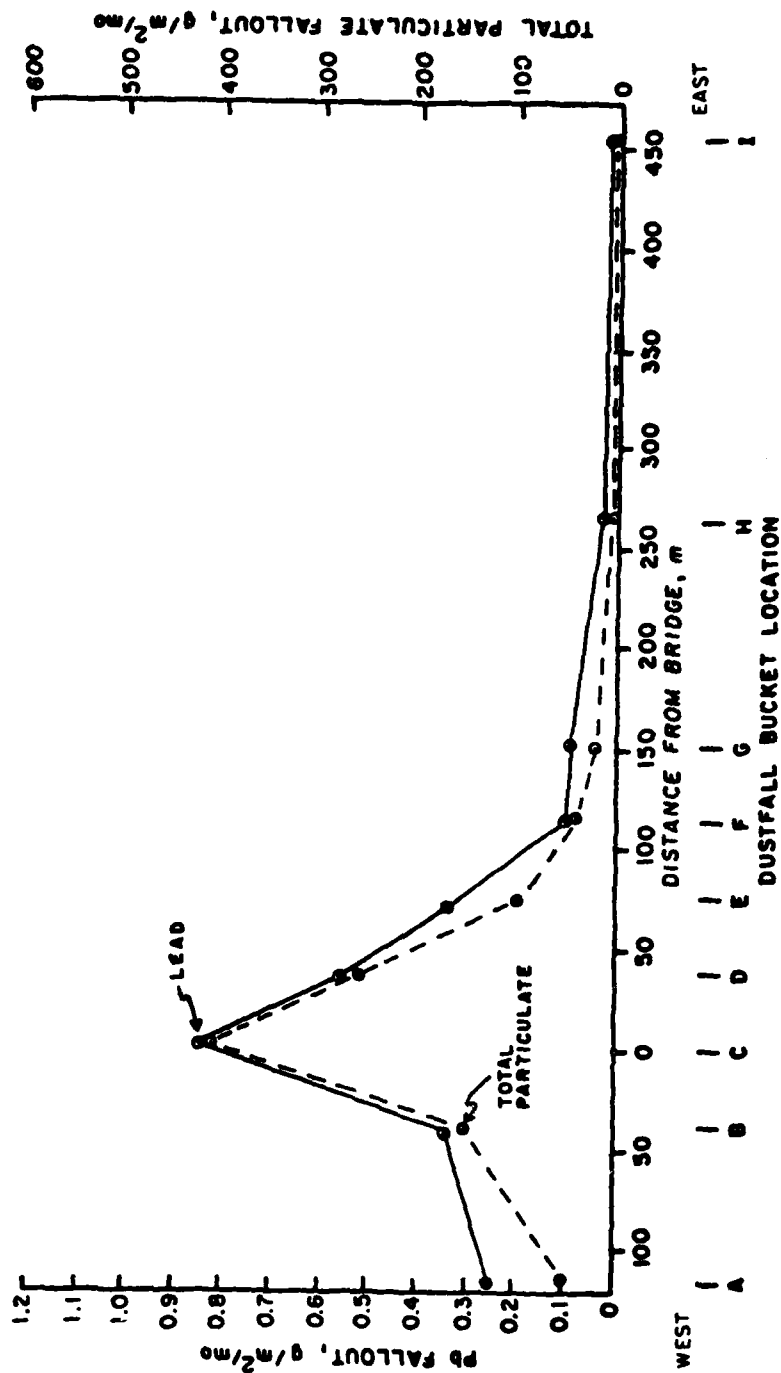
Figure 7. 14-month average Pb and particulate fallout profiles along the south side of the canal.

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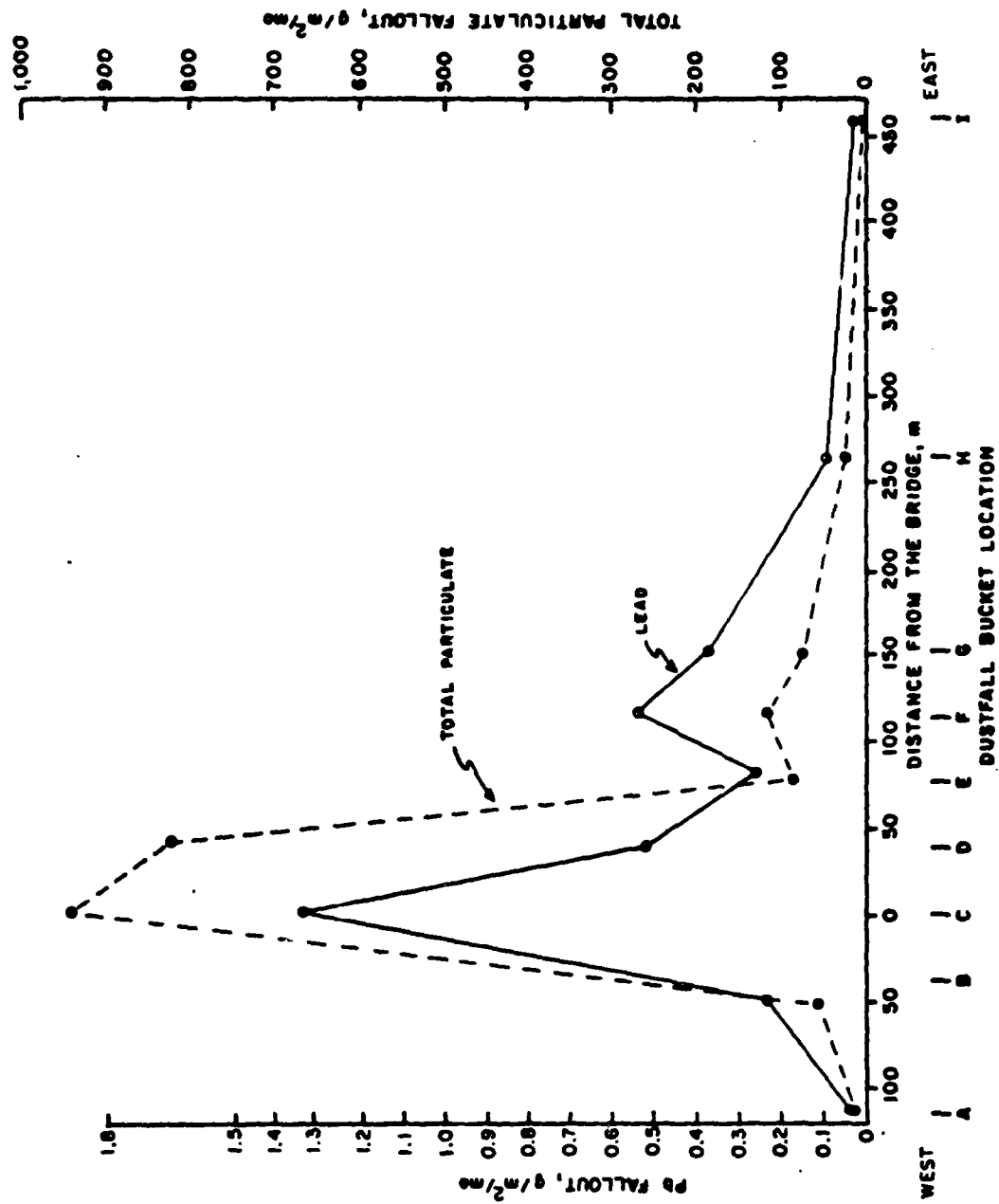Figure 8. 14-month average Pb and particulate fallout profiles along the north side of the canal.

Figure 9. Average Pb and particulate fallout profiles along the south side of the canal for months without sandblasting vs. months with ≥ 5 days sandblasting.
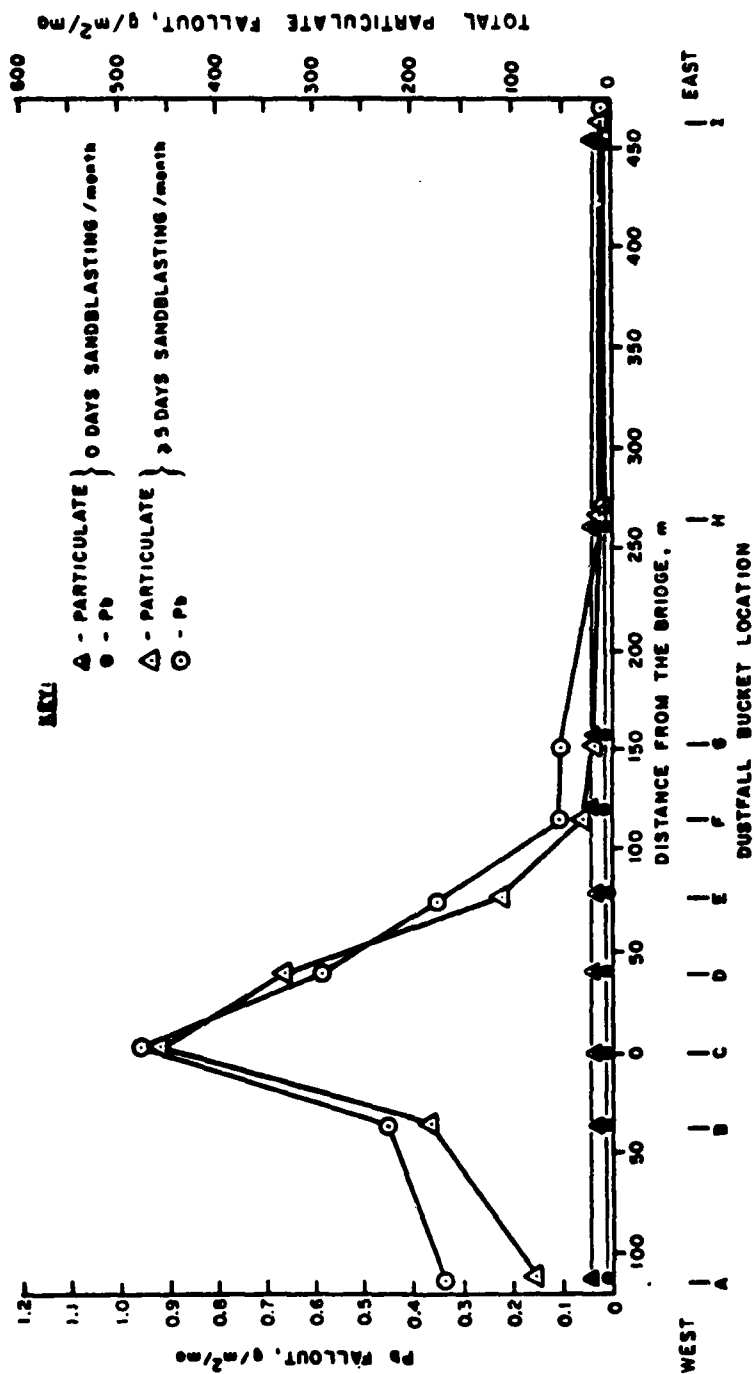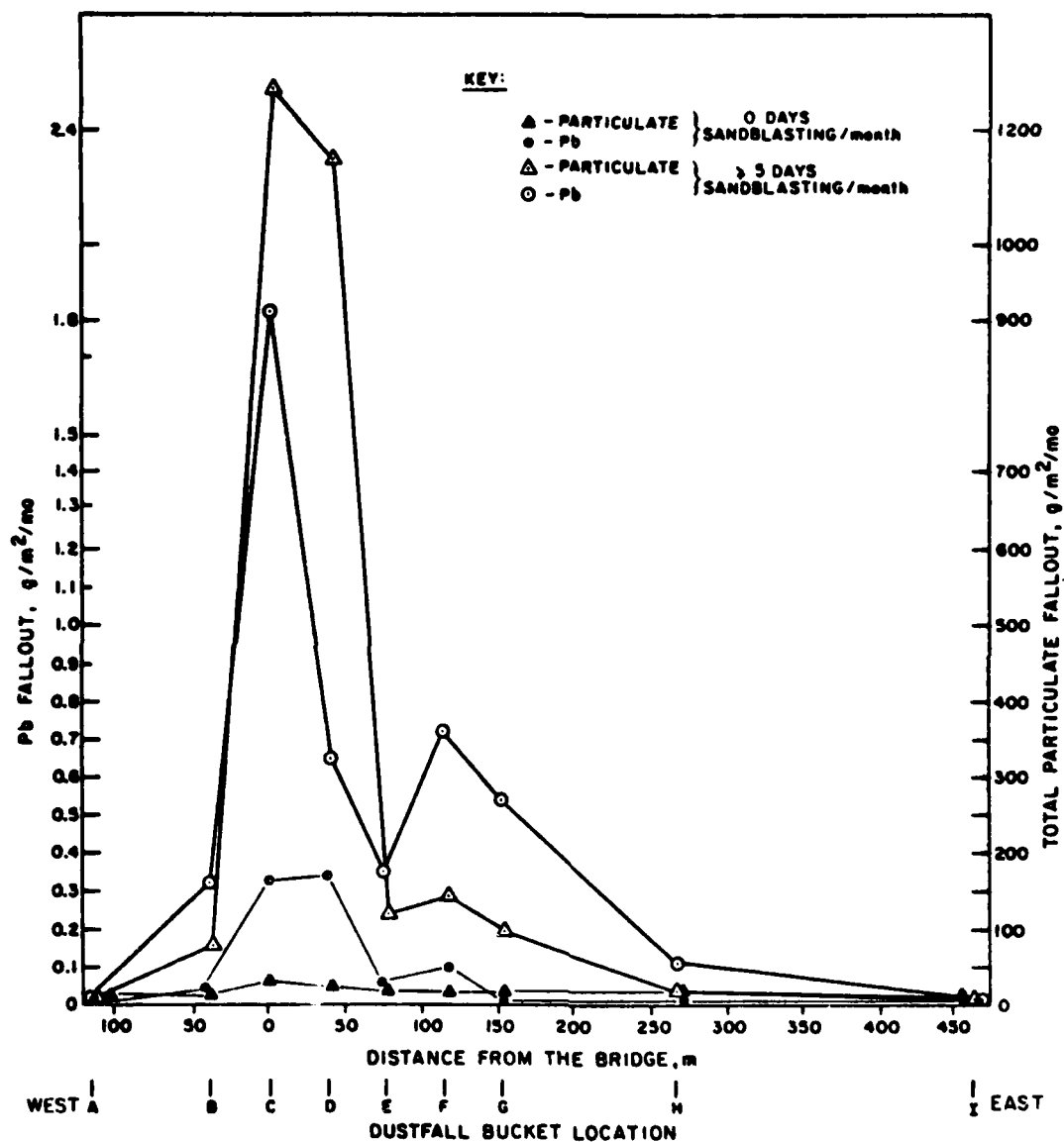
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Figure 10. Average Pb and particulate fallout profiles along the north
side of the canal for months without sandblasting vs.
months with >5 days sandblasting.

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August 1980), with concentrations during months with 5 or more days of sandblasting (December 1979; March, April, May, June, July, September, October, November, December 1980). The marked increase in the fallout rates of both lead and total particulate during months with sandblasting is immediately apparent from the figures. Secondly, the lack of data on the north side of the canal at Site E during October 1980 is again reflected by the asymmetry of the lead and particulate profiles. A third feature of note is the relatively high fallout of lead near the bridge on the north side of the canal during the months without sandblasting. Examination of the fallout data in Table D-2 (Appendix D) of these two months shows an average fallout rate for lead of only 1.5 mg/m^2/month in February, in contrast to an average rate of 215 mg/m^2/month in August. This large difference appears to be a result of increased bridge traffic in August. The average daily traffic volume across the bridge was 7,195 vehicles in February and 27,484 vehicles in August as shown in Table 6. A more modest increase, from 2.2 to 7.3 g/m^2/month, occurred in the average fallout rate of total particulates between February and August.

The fallout data from all of the buckets have been analyzed to determine whether the lead content of the particulate varied with the amount of material collected. To do this, the percent of the catch that was lead was calculated for each of the 245 observations. Next, the data were ordered by fallout rate and separated into 5 groups approximately equal in number. The range and geometric mean of the lead percentages in each group were then determined. The results, presented in Table 9, show that the percent of lead increased with increasing fallout rate through the first three groups, then decreased and remained roughly constant for the last two groups. The geometric mean for all samples is 0.23 percent lead. The percent lead within each of the five groups varied as shown by the frequency distributions presented in Table 10.

TABLE 9. LEAD CONTENT OF SETTLEABLE PARTICULATES
AS A FUNCTION OF PARTICULATE FALLOUT
RATE

Number of observations	Fallout rate (g/m^2/mo)	Percent Pb	
		Geom. mean	Range
50	0.2 - 2.5	0.130	0.005 - 2.300
48	2.6 - 5.8	0.221	0.011 - 6.639
49	5.9 - 22.0	0.371	0.015 - 5.358
49	22.4 - 94.5	0.202	0.005 - 3.671
49	101.1 - 10158.8	0.219	0.017 - 1.151
		0.229 average	

TABLE 10. FREQUENCY DISTRIBUTIONS OF PERCENT LEAD CONTENT OF
SETTLEABLE PARTICULATES

Class interval (percent lead)	Fallout rate (g/m²/mo)				
	0.2 - 2.5	2.6 - 5.8	5.9 - 22.0	22.4 - 94.5	101.1 - 10158.8
	Number of observations				
0.00 - 0.09	24	10	3	10	7
0.10 - 0.19	9	11	8	10	11
0.20 - 0.29	6	7	7	10	15
0.30 - 0.39	3	5	11	9	8
0.40 - 0.49	2	6	7	4	2
0.50 - 0.59			3		
0.60 - 0.69	1		1	1	1
0.70 - 0.79	2	2	1	1	1
0.80 - 0.89	1	1			1
0.90 - 0.99					1

1.00 - 1.99	1	2	4	1	2
2.00 - 2.99	1	3	1	2	
3.00 - 3.99				1	
4.00 - 4.99			2		
5.00 - 5.99			1		
6.00 - 6.99		1			
TOTAL	50	48	49	49	49

Additional summaries of the particle fallout data are presented in Appendix D. A summary of the 14 months of lead and particulate data is presented in Tables D-1 and D-2. Particle and lead fallout concentrations for 5 separate "days of sandblasting per month" groups have been prepared to show differences in fallout rates. The lead and particulate for the months included in each group are presented as averaged concentrations, in Figures D-1 through D-10.

SOURCE STRENGTH ESTIMATES

Estimates of the amount of material introduced into the atmosphere by sandblasting were determined from the two series of special measurements and expressed as pounds of particulate and lead per hour per sandblaster. A detailed account of the sampling equipment and procedures used in collecting the data and the method used to estimate source strength are presented in Appendix A.

The results of the first experiment, conducted on 2 and 3 April 1980, are summarized in Table 11. The source strength estimates are based on the total mass of the particulates collected by the hi-vols and its lead content, and on the amount of lead present in three size fractions. The cut point at which particles are sized (size cut) between the two cyclone catches is dependent upon flow rate and varies somewhat from run to run. The size cut at 125 μm diameter was achieved using a particle sizing sieve. On the average, the size fraction diameter ranges were: (1) less than 10 μm, (2) between 10 μm and 125 μm, and (3) greater than 125 μm. Of the total amount of lead collected, approximitely one-half was associated with the size fraction range between 10 and 125 μm, and the remaining half distributed roughly equally between the other two size fractions.

The source strength estimates for lead, averaged per run, during the three runs ranged from approximately 1.5 to 3.8 lb/hr per sandblaster, and averaged 2.7 lb/hr. The average total particulate source strength ranged from 57 to 248 lb/hr per sandblaster and averaged 133 lb/hr. The lead content of the particulates during the three test runs ranged from 1.1 percent to 4.0 percent, and averaged 2.7 percent.

More detailed source strength data was collected during the second experiment by using two simultaneously operated Inhalable Particulate Cyclone Samplers (IP Samplers) and a series of sizing sieves. Table 12 gives the sampling times and sampling rates for the two runs conducted on 21 and 22 October 1980, and Table 13 presents the source strength estimates by particle size range obtained from the two runs. The total amount of lead introduced into the atmosphere by one sandblaster was calculated to be 4.8 and 3.5 lb/hr during Runs 1 and 2, respectively, compared to the average of 2.7 lb/hr found from Experiment No. 1. Also, the average total particulate source strength was 345 lb/hr per sandblaster during Experiment No. 2 compared to 133 lb/hr during Experiment No. 1. A portion of the differences in the measured source strengths between the two experiments is believed to be a result of superior instrumentation and sampling techniques used during the October trials. A

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TABLE 11. SUMMARY OF SAMPLING DATA FOR SOURCE STRENGTH EXPERIMENT NO. 1

| | | | | | Source strength per sandblaster | | | | | |
| | | | | | Cyclone undersized catch | | Cyclone catch | | Oversized sieve catch | |
Date	Run #	Type of hi-vol	Total particulate (lb/hr)	Total Pb (lb/hr)	Pb (lb/hr)	Size cut (μm)	Pb (lb/hr)	Size cut (μm)	Pb (lb/hr)	Size cut (μm)
4/2/80	1	Regular	156.0	1.8	--	--	--	--	--	--
4/2/80	1	Cyclone	339.8	3.6	0.6	<13.1	2.2	13.1-125	0.8	>125
4/3/80	2	Regular	60.9	1.4	--	--	--	--	--	--
4/3/80	2	Cyclone	53.8	1.6	0.7	<8.0	0.7	8.0-125	0.2	>125
4/3/80	3	Regular	80.0	3.3	--	--	--	--	--	--
4/3/80	3	Cyclone	108.5	4.2	0.6	<8.4	1.9	8.4-125	1.7	>125
Source strength averages per sandblaster			133.2	2.7	0.7		1.6		0.9	

Note: The reported source strength data are normalized to hourly figures regardless of actual exposure time. This allows direct comparison of data between runs with different number of minutes exposure.

source strength of 345 lb/hr is approximately one-half of the amount of sand actually used by one sandblaster. When comparing these values, it should be borne in mind that substantial amounts of sandblasting material collected temporarily on the deck and that this material is not necessarily measured by the above sampling technique.

TABLE 12.   INHALABLE PARTICULATE CYCLONE SAMPLER OPERATION DURING SECOND SOURCE STRENGTH EXPERIMENT

Date	Run no. and sampler location	Total sampling time (min)	Sampling rate (aft^3/min)[a]
10/21/80	1-R	204.2	0.4084
10/21/80	1-L	203.4	0.4213
10/22/80	2-R	212.2	0.4331
10/22/80	2-L	211.1	0.4057

[a]aft^3/min = cubic feet per minute at actual conditions

The source strength data by size category given in Table 13 have been combined into cumulative percent frequency curves presented in Figure 11. These curves indicate that only about 7 percent of the total particulate captured by the samplers was less than 10 μm in diameter and that 11 percent of the lead was associated with this size fraction. Also of interest, only about 1.6 percent of the total particulate, containing 3 percent of the lead, was less than 2.5 μm in diameter, or respirable. Similarly, about 10 percent of the total particulate, containing 16 percent of the lead was less than 15 μm, or inhalable. Atmospheric turbulence is sufficient to keep particles less than about 10 μm in diameter suspended except under stable conditions with very light winds, whereas the settling of particles greater than about 100 μm in diameter is largely unimpeded by the effects of turbulence. The gravitational settling of intermediate size particles is somewhat impeded by atmospheric motions. Consequently, the larger particles associated with sandblasting can be expected to accumulate on the ground near the bridge, while perhaps 7 percent of the material becomes truly suspended in the atmosphere and behaves similar to a gas. A more detailed discussion of settling rates, wind speeds, and particle travel distances is included in Appendix C.

Table 14 presents the lead content of the particles, in percent, for the various size categories used in the second experiment. On the average, the lead content of the particles decreased with increasing diameter, being 2.5 percent for particles less than 2.4 μm in diameter and less than 1 percent for particles greater than about 75 μm in diameter.

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TABLE 13. SOURCE STRENGTH ESTIMATES FROM EXPERIMENT NO. 2

Run no. and sampler location	Particle size range (μm)													
	0 - 2.4		2.4 - 14.6		14.6 - 45		45 - 75		75 - 125		>125		Total	
	Pb	TP	Pb	TP	Pb	TP	Pb	TP	Pb	TP	Pb	TP	Pb	TP
	Source strength (lb/hr)													
1-R	0.1	4	0.3	31	0.2	19	1.8	154	0.3	47	1.5	102	4.2	357
1-L	0.1	6	0.4	36	1.4	94	1.0	92	0.6	71	1.9	253	5.4	552
Average	0.1	5	0.35	33.5	0.8	56.5	1.4	123	0.45	59	1.7	178	4.8	455
2-R	0.2	4	0.7	30	1.8	108	0.4	29	0.1	14	0.2	34	3.4	219
2-L	0.1	6	0.6	31	1.8	84	0.7	45	0.2	25	0.3	62	3.7	253
Average	0.15	5	0.65	30.5	1.8	96	0.55	37	0.15	19.5	0.25	48	3.5	236

Note: Values identified as total particulate, TP, are based on the total amount of particulate collected by the sampler, including lead.

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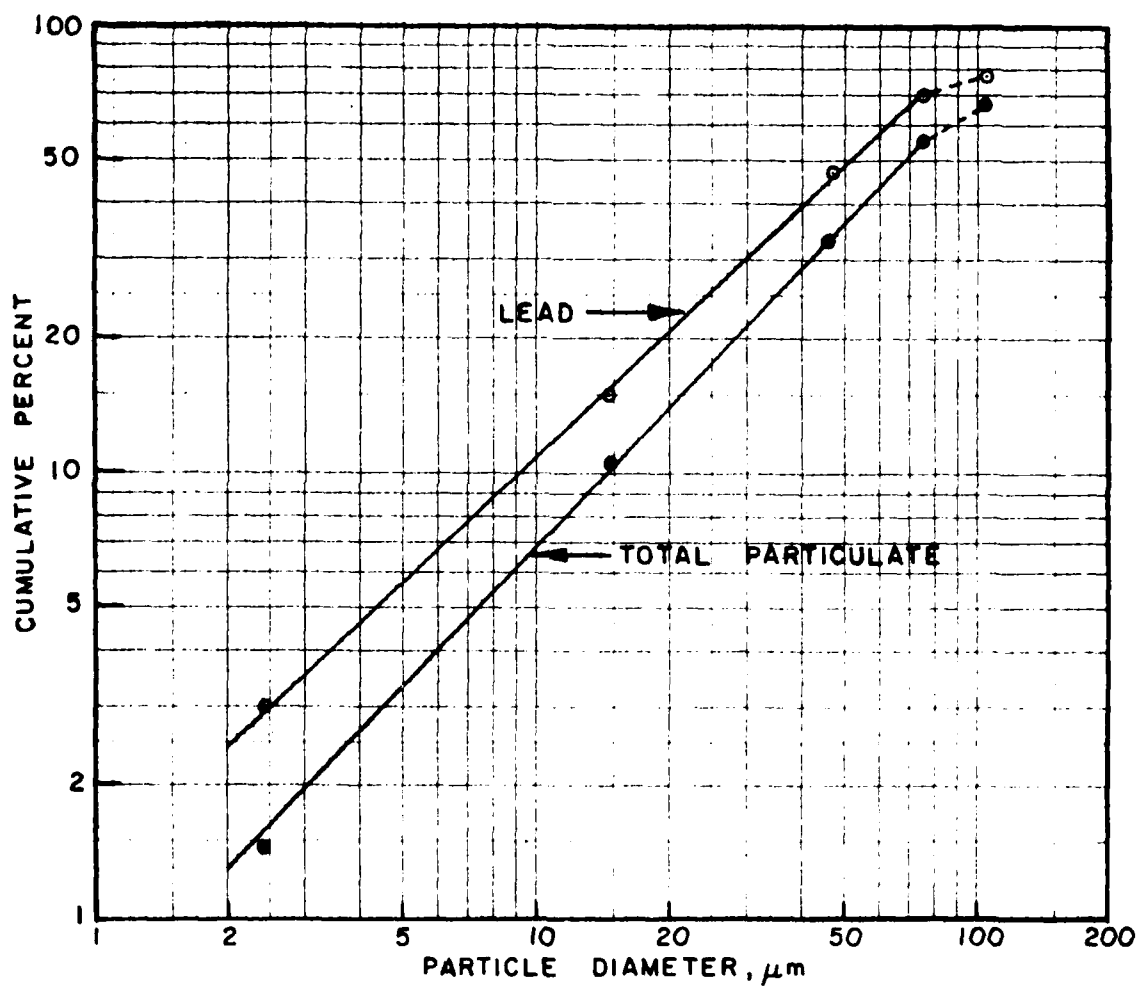
Figure 11.   Cumulative percent of Pb and particulate by
particle diameter – source strength experiment
No. 2.

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TABLE 14. LEAD CONTENT OF AIRBORNE MATERIAL DETERMINED
DURING SECOND SOURCE STRENGTH EXPERIMENT

Particle size range (µm)	Lead content (percent)		
	Run No 1	Run No 2	Average
0 - 2.4	2.0	3.0	2.5
2.4 - 14.6	1.0	2.1	1.6
14.6 - 45	1.4	1.9	1.6
45 - 75	1.1	1.5	1.3
75 - 125	0.8	0.8	0.8
> 125	1.0	0.5	0.7
Average	1.2	1.6	1.4

SECTION 4

SUMMARY OF PRINCIPAL FINDINGS

The predominant amount of particulate generated during sandblasting was sufficiently large in particle size to be strongly affected by gravitational settling. As a result, the highest concentrations of lead and particulate were recorded at the downwind sites closest to the sandblasting. These concentrations were, however, generally very low in comparison to the Federal and State ambient air quality standards.

Analysis of the data collected during the monitoring program resulted in the following specific findings:

HI-VOL NETWORK

- The highest observed arithmetic average lead concentration over a calendar quarter was 0.17 $\mu g/m^3$, approximately one-ninth of the standard (1.5 $\mu g/m^3$).

- The highest observed 12-month average TSP concentration was 33 $\mu g/m^3$. This is to be compared to the primary and secondary standards of 75 $\mu g/m^3$ and 60 $\mu g/m^3$, respectively.

- No violation of the primary 24-hour average TSP standard of 260 $\mu g/m^3$ occurred at any site.

- Seven exceedances of the secondary 24-hour average TSP standard (150 $\mu g/m^3$) were recorded by the network downwind from ongoing sandblasting activity. Four of these occurred at Site 5, close to and downwind from sandblasting; one each occurred at Sites 2, 3 and 4. Since the standard allows one exceedance per year, the standard was violated only at Site 5.

FALLOUT NETWORK

- The greatest fallout of lead and particulate took place directly beneath the bridge on the north and south sides of the canal. It was heavier on the north side, with the highest north side value at each site being approximately twice the corresponding south side value.

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- The highest fallout rate of lead, averaged over the 14-month sampling period at a single site, was 1.3 g/m^2/mo. The highest fallout rate of lead for any one-month period at a single site was 8.0 g/m^2/mo.

- The highest fallout rate of particulate, averaged over the 14-month sampling period at a single site, was 939 g/m^2/mo. The highest fallout rate of particulate for any one-month period at a single site was 10,159 g/m^2/mo.

- The geometric mean lead content of all of the fallout samples was 0.23 percent. The mean lead content increased from a minimum of 0.13 to a maximum of 0.37 percent as the fallout rate increased from 0.2 to 22.0 g/m^2/mo; for the higher fallout rates of 22.4 to 10,159 g/m^2/mo, the mean lead content dropped and averaged 0.21 percent.

SOURCE STRENGTH MEASUREMENTS

- The amount of lead and particulate introduced into the atmosphere by one sandblaster was estimated to be 2.7 and 133 lb/hr, respectively, during the first experiment, and 4.2 and 345 lb/hr, respectively, during the second experiment.

- Seven percent of the particulate captured by the samplers were less than 10 µm in diameter; these small particles disperse as a gas in the atmosphere except under stable conditions and very light wind speeds. Eleven percent of the lead was associated with this size fraction.

- About 1.6 percent of the particulate, containing 3 percent of the lead, was less than 2.5 µm in diameter, or respirable.

- About 10 percent of the particulate containing 16 percent of the lead was less than 15 µm in diameter, or inhalable.

- The average lead content of all particulate size fractions was 1.4 percent.

SECTION 5

REFERENCES

1. Environmental Protection Agency Regulations on National Primary and
    Secondary Ambient Air Quality Standards. (40 CFR 50; 36 CFR 22384,
    November 25, 1971; as amended by Code of Federal Regulations, Volume 40,
    revised as of July 1, 1976; 41 FR 52686, December 1, 1976; 43 FR 46258,
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2. Environmental Protection Agency Regulations on National Primary and
    Secondary Ambient Air Quality Standards. (40 CFR 50; 36 CFR 22384,
    November 25, 1971; as amended by Code of Federal Regulations, Volume 40,
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    Standards, Washington, D.C. NBSIR 73-256, October 1973.

6. Turner, D. B. Workbook of Atmospheric Dispersion Estimates. U.S.
    Department of Health, Education, and Welfare, Cincinnati, Ohio, 1969.

APPENDIX A

SOURCE-STRENGTH PARTICLE SIZING MEASUREMENT PROGRAM

Two sets of measurements were conducted during the first year of testing
to characterize the particulate introduced into the atmosphere during
sandblasting by particle size, lead content, and generation rate. The first
set of measurements, conducted on 2 and 3 April 1980, in Span 7, bays 4 and 7,
respectively, was comprised of 3 runs. In each run, two monitors were placed
downwind of the sandblasting activity on the outside perimeter of the
temporary flooring located approximately 7 feet beneath the bridge. Figure
A-1 shows the location of the samplers. Figure 6 in Section 2 of this report
shows a photograph of the installation.

Each of the 3 runs sampled the material generated by a single sandblaster
blasting the painted steel structure directly beneath the road surface. Run 1
was 94 minutes in length and the wind speed through the bay during the run
averaged 15.5 mph (6.9 m/sec), Run 2 was 26 minutes with 9.5 mph (4.2 m/sec)
average wind speed, and Run 3 was 65 minutes with 10.0 mph (4.5 m/sec) average
wind speed. The monitors were located approximately in the center of the 12.5
m^2 plane that constituted the exit for the sandblasting plume. Because the
sandblaster traversed continually back and forth upwind of the monitors, this
sampling process was thought to provide an adequate representation of the
average concentration of particulates in the air as it left the bay.

A regular hi-vol fitted with a 3-inch orifice (see Figure 6) was operated
at approximately 29 aft^3/min (0.82 m^3/min) and collected particulate on a
standard glass fiber filter. Another hi-vol, equipped with a Sierra
Instruments Model 230 CP Cyclone Preseparator, separated the particulate into
two size fractions. The particles small enough to pass the separator were
_ullected on the glass fiber backup filter (the cyclone undersized catch) and
the larger particles were collected in the cyclone (the cyclone catch). The
actual size cut for the cyclone is dependent on the flow rate, which varied
slightly from run to run, providing slight variation in the cut points. The
cyclone catch was sieved through a 125 μm screen sieve providing an additional
size fraction (the oversized sieve catch).

On 21 and 22 October 1980, the second set of measurements was conducted
on the Bourne Bridge, using two simultaneously run Inhalable Particulate
Cyclone Samplers (IP Samplers) during each run. The IP sampler was designed
for stack sampling and each consists of two stainless steel cyclones and a
backup filter, in series, which can be connected directly to an EPA Method 5
or 17 sampling train. The cyclones are designed to provide a leak-free system.
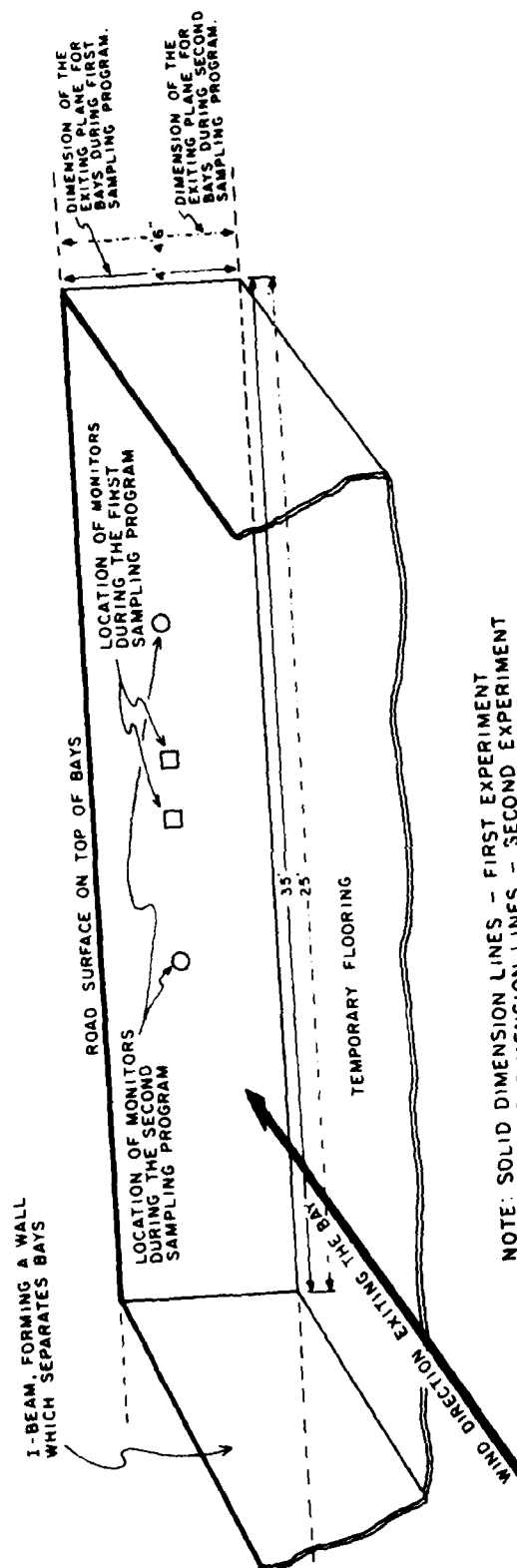
Figure A-1. Diagram of a bay during source-strength sampling.

DIMENSION OF THE EXITING PLANE FOR BAYS DURING FIRST SAMPLING PROGRAM.

DIMENSION OF THE EXITING PLANE FOR BAYS DURING SECOND SAMPLING PROGRAM.

LOCATION OF MONITORS DURING THE FIRST SAMPLING PROGRAM

ROAD SURFACE ON TOP OF BAYS

LOCATION OF MONITORS DURING THE SECOND SAMPLING PROGRAM

I-BEAM, FORMING A WALL WHICH SEPARATES BAYS

TEMPORARY FLOORING

EXITING THE BAY

WIND DIRECTION

35'

25'

6'

NOTE: SOLID DIMENSION LINES – FIRST EXPERIMENT
      DASHED DIMENSION LINES – SECOND EXPERIMENT

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The first and second cyclones exhibit 50 percent efficient particle size cutpoints of approximately 15 μm and 2.5 μm, respectively. The last stage is the backup filter which catches all the particulate smaller than approximately 2.5 μm. The cutpoints of the two cyclones are a function of the velocity of the gas through the sampler. Determination of the correct flow rate is based on the viscosity of the gas through the cyclone. The IP sampler was designed by Southern Research Institute, Birmingham, Alabama. Specifications and operating principles can be found in the procedures manual.

The sampling was conducted in Span 6, bays 5-6 and 3-4 on 21 and 22 October, respectively. The two samplers were located downwind of the sandblasting activity on the outside perimeter of the temporary flooring (see Figure 6) and were vertically centered and equally spaced across the bay (Figure A-1). An average flow rate of 0.42 aft^3/min was maintained through a 14.5 mm diameter nozzle. The samplers were operated continuously during sandblasting operations except for periods when the sandblaster stopped working. The length of the sampling periods ranged from 203 to 212 minutes.

The IP sampler, combined with particle sizing sieves used during the laboratory analysis, separated the particulate into the following size categories: 0-2.4 μm, 2.4-14.6 μm, 14.6-45 μm, 45-75 μm, 75-125 μm, and >125 μm. Gravimetric and chemical analysis of the particulate provided weights of total particulate and lead, respectively, for each size category. Quality control measures were exercised throughout the analyses. The procedures followed in carrying out the chemical analysis are presented in Appendix B.

Once the concentration of Pb or total particulate in the air leaving the bay was determined from its weight and the volume of air passing through the sampler, the rate at which the material was generated (source strength) was calculated from the following relationship:

$$\text{Source Strength } (\mu g/sec) = X \times \bar{U} \times A$$

where: X = concentration of Pb or particulate in μg/m^3

$\bar{U}$ = average wind speed through the bay in m/sec

and A = area of the exiting plane (bay cross section) in m^2.

The source strengths calculated by this equation were converted into the more appropriate units of lb/hr for inclusion in Tables 11 and 13 of Section 3.

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APPENDIX B

LEAD ANALYTICAL PROCEDURE

Preparation--Nitric Acid Extraction[2]

An aliquot of the filter (one quarter of a Hi-Vol filter) is placed in a 150 ml beaker by cutting it into approximately 1-inch squares. Enough 3M HNO_3 acid is added to the beaker to completely cover the filter. The beaker is heated in a hood and boiled gently for 30 minutes. After boiling, the solution is cooled and the acid decanted. Distilled-deionized water (DDW) is added to the beaker to rinse the filter and beaker. After adding DDW, the beaker is set aside for 30 minutes. After this time, the DDW is decanted and combined with the original 3M HNO_3. The combined solutions are evaporated to a volume below 25 ml. The solution is decanted into a 25 ml volumetric flask and brought to volume with DDW.

Analysis

Lead in the acid extract is analyzed by atomic absorption spectroscopy. The atomic absorption conditions for analysis include an air-acetylene flame and detection at 283 nm. Standard solutions, containing lead nitrate, are utilized for calibration purposes and a calibration is normally conducted before each set of samples is analyzed.

QUALITY CONTROL PROCEDURES

A total of 115 spiked filters were submitted for quality control analyses during the project. The results listing the percent recovery are presented in Table B-1. Of the 115 filters submitted, six were lost due to errors in spiking or analysis. The average recovery for the remaining filters was 94 ±10 percent.

Quality control procedures for this program involved analysis of hi-vol filters spiked with known quantities of lead nitrate.[5] Both known and "blind" quality control samples were submitted for analysis. Known control samples were prepared and if the results were acceptable, analysis was allowed to proceed. "Blind" quality control samples, those unrecognizable to the analyst, were submitted at the time samples were received at the sample bank. In addition to the procedures detailed above, the laboratory participated in two EPA Interlaboratory Surveys for Lead on Hi-Vol Filters during this project. The results of these two studies in July 1980 and January 1981 are presented in Figures B-1 and B-2, respectively.

TABLE B-1.   PERCENT RECOVERY OF Pb FROM SPIKED HI-VOL FILTERS

Sample No.	Reported value (µg)	Expected value (µg)	Percent recovery	Sample No.	Reported value (µg)	Expected value (µg)	Percent recovery
Pb-1	500	500	100%	Pb-21	200	300	67%
Pb-2	300	300	100%	Pb-22	230	250	92%
Pb-3	310	300	102%	Pb-23	190	200	95%
Pb-4	480	500	96%	Pb-24	280	300	93%
Pb-5	500	500	100%	Pb-25	280	300	93%
Pb-6	320	300	107%	Pb-26	130	200	65%
Pb-7	300	300	100%	Pb-27	280	400	70%
Pb-8	250	250	100%	Pb-28	330	400	83%
Pb-9	250	250	100%	Pb-29	440	500	88%
Pb-10	470	500	94%	Pb-30	250	300	83%
Pb-11	140	200	70%	Pb-31	280	300	93%
Pb-12	190	200	95%	Pb-32	Spiking error		
Pb-13	190	200	95%	Pb-33	Spiking error		
Pb-14	180	200	90%	Pb-34	230	300	77%
Pb-15	180	200	90%	Pb-35	500	500	100%
Pb-16	260	300	87%	Pb-36	280	300	93%
Pb-17	230	250	92%	Pb-37	300	300	100%
Pb-18	230	250	92%	Pb-38	Spiking error		
Pb-19	440	500	88%	Pb-39	Spiking error		
Pb-20	Sample lost			Pb-40	300	300	100%

(continued)

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Sample No.	Reported value (µg)	Expected value (µg)	Percent recovery	Sample No.	Reported value (µg)	Expected value (µg)	Percent recovery
Pb-41	200	200	100%	Pb-79	40	40	100%
Pb-42	430	400	108%	Pb-80	53	50	106%
Pb-43	400	400	100%	Pb-81	1100	1000	110%
Pb-44	280	300	93%	Pb-82	2200	2000	110%
Pb-45	83	100	83%	Pb-83	5600	5400	104%
Pb-46	190	200	95%	Pb-84	1860	1800	103%
Pb-47	270	300	90%	Pb-85	18	20	90%
Pb-48	210	200	105%	Pb-86	20	20	100%
Pb-49	190	200	95%	Pb-87	30	40	75%
Pb-50	300	300	100%	Pb-88	48	50	96%
Pb-51	280	300	93%	Pb-89	730	1000	73%
Pb-52	70	100	70%	Pb-90	1300	1500	87%
Pb-53	180	200	90%	Pb-91	50	40	125%
Pb-54	140	200	70%	Pb-92	50	50	100%
Pb-55	380	400	95%	Pb-93	1100	1000	110%
Pb-56	210	200	105%	Pb-94	580	500	116%
Pb-57	300	300	100%	Pb-95	110	100	110%
Pb-58	380	400	95%	Pb-96	50	50	100%
Pb-59	460	500	92%	Pb-97	980	1000	98%
Pb-60	300	300	100%	Pb-98	20	20	100%
Pb-61	380	400	95%	Pb-99	35	40	88%
Pb-62	240	250	96%	Pb-100	28	30	93%
Pb-63	390	350	111%	Pb-101	Blank	Blank	–
Pb-64	240	250	96%	Pb-102	53	50	106%
Pb-65	140	150	93%	Pb-103	2000	2000	100%
Pb-66	40	50	80%	Pb-104	40	40	100%
Pb-67	Spiking error			Pb-105	48	50	96%
Pb-68	68	80	85%	Pb-106	43	50	86%
Pb-69	40	50	80%	Pb-107	30	40	75%
Pb-70	93	100	93%	Pb-108	55	66	88%
Pb-71	21	20	105%	Pb-109	80	87	92%
Pb-72	75	80	94%	Pb-110	140	160	88%
Pb-73	74	80	93%	Pb-111	700	720	97%
Pb-74	170	200	85%	Pb-112	75	72	104%
Pb-75	180	200	90%	Pb-113	55	58	95%
Pb-76	19	20	95%	Pb-114	129	140	92%
Pb-77	25	20	125%	Pb-115	96	88	109%
Pb-78	40	40	100%				

INTER-LABORATORY STUDY RESULTS

DATE PRINTED: 08/11/80

(JULY 1980)

POLLUTANT - PB

UNITS - MICROGRAMS PER CUBIC METER

564005
MS. ROSEMARY ELLERSICK, QA MGR.
GCA TECHNOLOGY DIV.
BURLINGTON ROAD
BEDFORD, MA 01730

SAMPLE NUMBER	REPORTED VALUE	EPA VALUE	PERCENT DIFFERENCE
0096	.420	.600	3.33
1096	7.400	6.600	12.12
2096	1.700	1.800	-5.56
3096	6.200	5.400	14.81
4096	3.400	3.000	13.00
5096	4.550	4.200	7.06

EPA RESULTS

.782   2.604   4.425   6.247   7.704
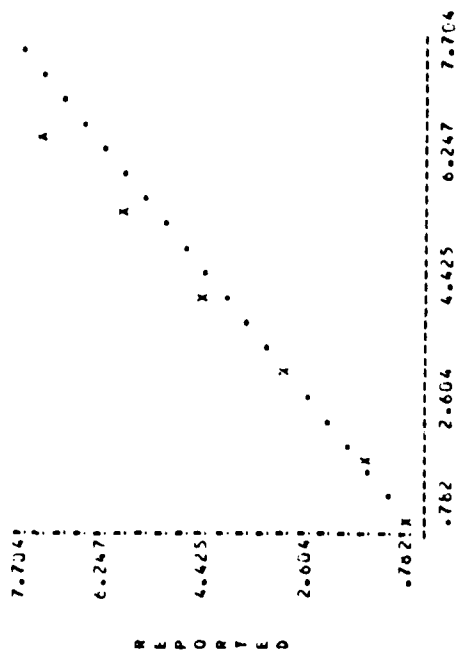
Y = 1.157X -0.210

Figure B-1. EPA interlaboratory survey for lead on hi-vol filters,
July 1980.

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(JANUARY 1981)

POLLUTANT - PB

UNITS - MICROGRAMS PER CUBIC METER

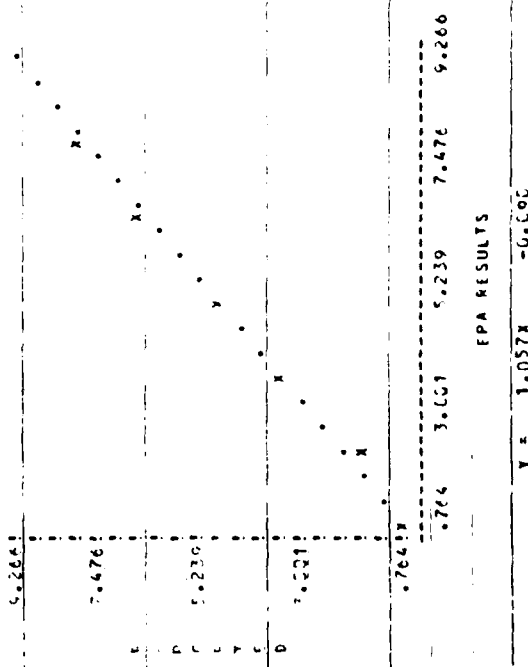| SAMPLE NUMBER	REPORTED VALUE	EPA VALUE	PER ENT DIFFERENCE
	.545	.585	-7.60
	2.100	2.040	2.94
	3.600	3.460	3.45
	5.000	4.980	.40
	7.000	6.585	6.30
	9.300	7.050	4.40

EPA RESULTS

Figure B-2. EPA interlaboratory survey for lead on hi-vol filters,
January 1981.

APPENDIX C

INFLUENCE OF GRAVITATIONAL SETTLING AND ATMOSPHERIC DISPERSION ON THE DISTRIBUTION OF SANDBLASTING MATERIAL

Particles introduced into the atmosphere during sandblasting operations are subject to gravitational settling, transport by the mean wind, and dispersion by atmospheric turbulence. The terminal velocity of spheres falling through the atmosphere can be calculated from their density and diameter. Table C-1 shows that the terminal velocity of such particles increases rapidly as the diameter increases from 20 µm to 90 µm and as the density increases. For illustrative purposes, terminal velocities are shown for particles with the approximate density of sand (2.0 g/cm^3) and for two higher densities representative of particles bearing significant amounts of lead. Paint particles would be more likely to be in the form of chips and flakes than spheres, however, and would be expected to settle at somewhat lower rates than spheres of equal density.

TABLE C-1. TERMINAL VELOCITY OF SPHERES

Density, g/cm^3	Diameter of Sphere, µm							
	20	30	40	50	60	70	80	90
Terminal Velocity, m/sec								
2.0	0.023	0.052	0.094	0.145	0.205	0.265	0.320	0.370
3.5	0.040	0.094	0.160	0.240	0.315	0.450	0.480	0.560
5.0	0.060	0.125	0.220	0.315	0.410	0.505	0.610	0.720

The horizontal distance that particles settling in the atmosphere will be transported by the mean wind before reaching the earth's surface can be estimated from the release height, mean wind speed and terminal velocity. Typical release heights (i.e., height of sandblasting of main bridge structure above ground or water level) ranged from about 10 m at the north end of the bridge to about 30 m at the center span. Typical wind speeds recorded at the

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Corps of Engineers Canal Administration Building during sandblasting ranged from 2 m/sec to 7 m/sec. Figure C-1 shows transport distances of spherical particles for 3 release heights and 3 wind speeds as a function of particle size. A particle density of 2.0 g/cm^3 has been assumed, because of the low percentage (1.4) of Pb in the particulate. Because of their lower settling velocities, particles less than about 10 µm in diameter follow the turbulent motions of the atmosphere and diffuse much like a gas. Downwind concentrations from point sources of these fine particles can be calculated using standard Gaussian dispersion models and appropriate meteorological data.[6] Under typical daytime meteorological conditions at the bridge site, and a release height of 20 m, the maximum ground level concentration of particles <10 µm in diameter can be expected at distances of 200-300 meters, while the maximum impact of larger, heavier particles would occur closer to the source.

The important part played by wind speed and associated atmospheric turbulence on the behavior of particles introduced into the atmosphere is illustrated by Figure C-2 which relates particle diameter to three settling/ suspension regimes at wind speeds up to 18 mph (8.0 m/sec). The area labeled "suspension" represents particles that have the potential for long range transport. The area labeled "unimpeded settling" represents particles with terminal velocities sufficient to largely overcome the effects of turbulence and horizontal transport. Particles in the "impeded settling" area respond significantly to atmospheric motions while settling.

When the size distribution of the particles generated by sandblasting operations (as determined by the source strength measurement program) is considered in conjunction with the preceding qualitative discussion, it is clear why the maximum influence of the sandblasting activity on air quality occurred in the immediate vicinity of the bridge. Reference to Figure 11 shows that only 7 percent of the particulates sampled were <10 µm, and that as much as half of the sandblasted material was comprised of particles >65 µm in diameter. The fact that most of this material reached ground level within 100 m of the bridge structure is clearly demonstrated by the fallout curves of Figures 9 and 10. The very rapid decrease of concentration with distance is also shown by the hi-vol data for selected days contained in the Biweekly Reports submitted under the contract. For example, on 21 October 1980, Sites 4 and 5 were both downwind from sandblasting, but at significantly different downwind distances. Site 5, which was at a distance of 125 m, reported a TSP concentration of 195 µg/m^3, while Site 4, at a distance of 275 m, reported a concentration of 31 µg/m^3, essentially the same as concentrations at the remaining three sites (27, 29 and 29 µg/m^3). A lead concentration of 0.69 µg/m^3 was measured at Site 5 compared to 0.21 µg/m^3 at Site 4. Lead concentrations at the remaining sites were 0.27, 0.29, and 0.23 µg/m^3.
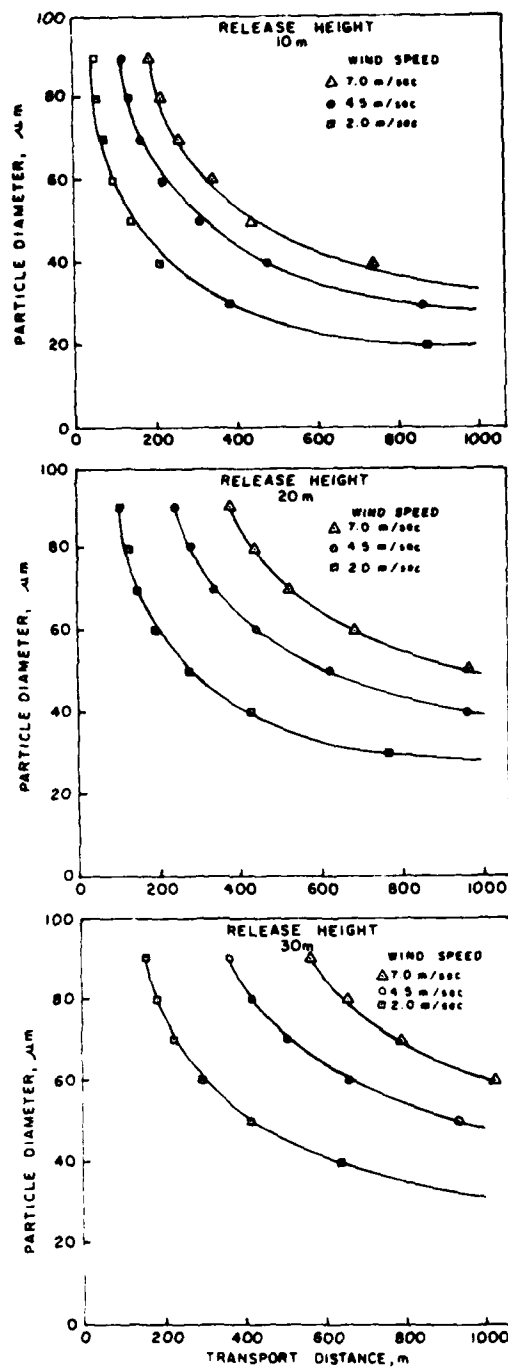
49

Figure C-1. Relationship between particle diameter and horizontal
transport distance for 3 wind speeds and different
release heights. Particles are assumed to be spherical
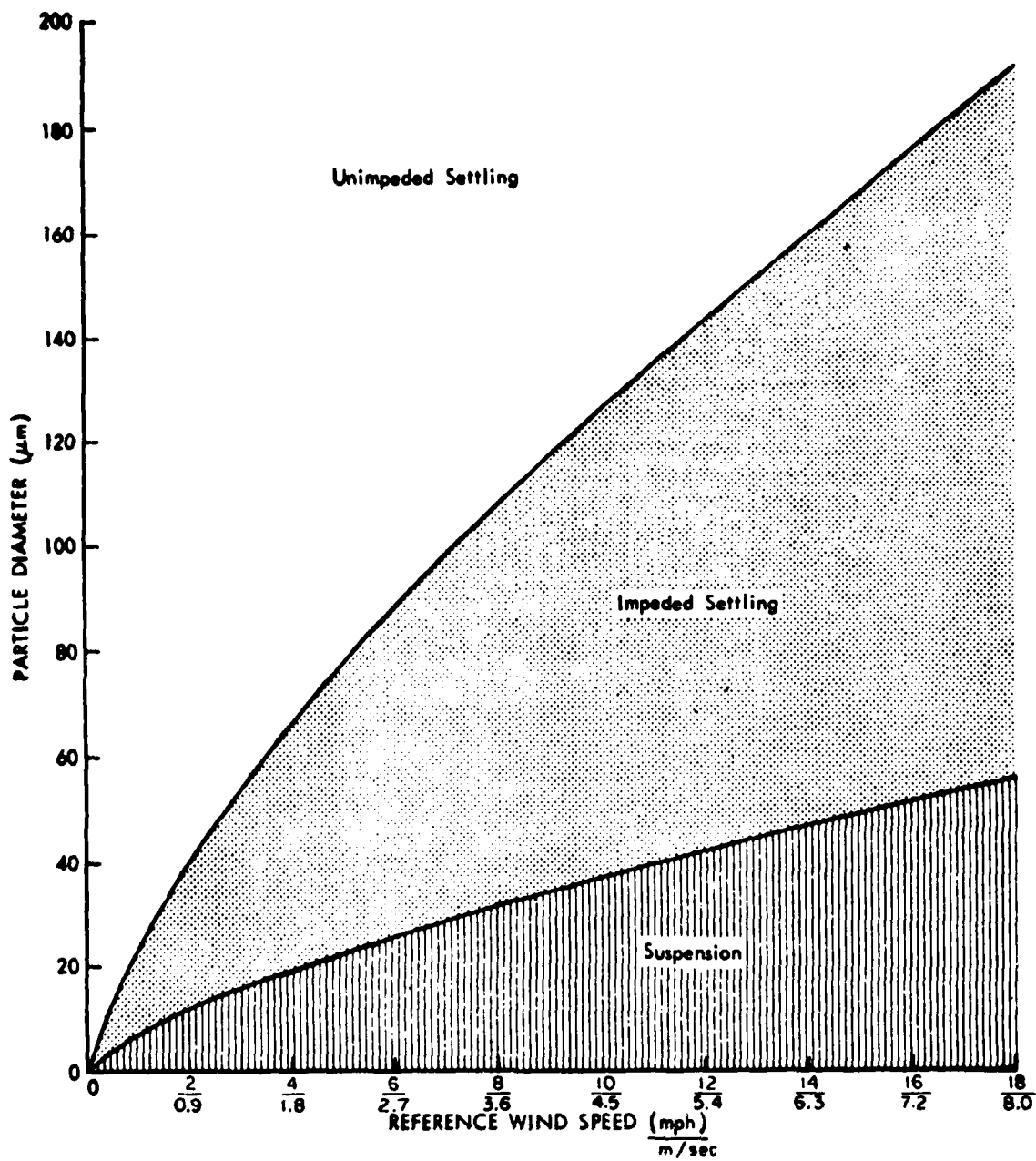and to have a density of 2.0 g/cm^3.

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Figure C-2. Particle settling/suspension regimes. (Taken from
C. Cowherd, Jr., K. Axetell, Jr., C. M. Guenther,
and G. A. Jutze. Development of Emission Factors
for Fugitive Dust Sources. EPA-450/3-74-037. Mid-
west Research Institute. Kansas City, Missouri.
June 1974).

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APPENDIX D

PARTICLE FALLOUT DATA

TABLE D-1. TOTAL PARTICULATE FALLOUT DATA

G/m² /MONTH

6 DECEMBER 1979 THROUGH 3 FEBRUARY 1981

SITE	DEC 1	JAN 2	FEB 3	MAR 4	APR 5	MAY 6	JUN 7	JUL 8	AUG 9	SEP 10	OCT 11	NOV 12	DEC 13	JAN 14
SA	1.2	1.6	4.5	199.0	211.5	261.7	11.7	3.2	2.2	6.1	14.4	2.3	2.0	2.8
SB	6.9	9.3	3.8	968.1	329.4	163.8	36.3	0.2	1.5	11.7	289.4	28.3	2.0	3.2
SC	72.8	.	6.0	1571.8	108.8	457.4	685.9	14.9	5.2	318.3	478.3	765.9	107.8	66.1
SC	32.2	307.4	4.0	526.9	172.3	631.9	1220.7	7.2	4.0	106.8	204.7	355.0	59.2	73.5
SE	12.2	219.8	2.0	289.7	108.8	119.0	223.6	5.7	2.7	32.3	199.7	94.5	12.1	41.7
SF	4.9	52.5	1.7	73.2	54.4	19.6	66.5	6.9	0.6	15.5	82.9	39.7	4.9	21.9
SE	1.7	31.6	1.5	43.8	22.4	39.7	30.2	9.4	1.3	6.5	47.0	15.5	3.1	20.9
SM	0.8	2.9	1.2	35.1	4.5	6.9	7.3	4.5	1.2	1.4	30.3	.	1.2	4.4
SI	0.7	0.8	0.9	26.4	2.1	4.2	5.8	4.0	4.4	3.0	2.1	0.7	0.6	7.1
HA	0.7	1.4	1.4	2.9	33.3	15.9	1.2	3.1	.	8.0	52.1	7.5	1.4	4.1
HB	2.4	4.1	2.2	20.5	57.4	338.4	15.1	3.7	5.8	17.3	263.3	93.1	1.7	7.4
HC	5.5	3.4	3.7	52.7	17.5	293.4	12.1	62.1	23.1	242.8	6409.0	4189.2	196.5	749.9
HE	23.9	22.0	4.4	32.1	25.4	777.3	12.1	14.0	14.6	41.9	10158.8	261.1	94.4	101.1
HF	3.8	28.6	2.2	5.9	48.3	782.6	10.2	10.1	4.0	38.8	.	135.5	35.3	30.1
HG	5.2	5.8	1.6	5.9	136.0	536.7	6.3	38.6	3.3	7.7	711.4	83.7	13.2	16.6
HH	1.2	2.5	1.8	8.8	151.0	343.7	21.4	11.8	3.2	5.6	321.9	52.3	.	21.6
HI	.	1.6	1.3	8.8	24.2	34.3	3.9	2.6	3.1	2.4	44.5	12.4	1.6	3.7
HJ	0.6	1.3	1.0	2.9		8.7	3.0	2.7	1.0	3.7	16.2	2.5	0.5	1.8

NOTE: . MEANS MISSING DATA.

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TABLE D-2. TOTAL LEAD FALLOUT DATA

G/m² /MONTH

6 DECEMBER 1979 THROUGH 3 FEBRUARY 1981

SITE	DEC 1	JAN 2	FEB 3	MAR 4	APR 5	MAY 6	MONTH JUN 7	JUL 8	AUG 9	SEP 10	OCT 11	NOV 12	DEC 13	JAN 14
SA	0.0039	0.0035	0.0011	0.6732	2.1151	0.4495	0.0544	0.0061	0.0411	0.0161	0.0332	0.0088	0.0001	0.0045
SB	0.3160	0.1098	0.0076	2.2247	0.7856	0.3172	0.1249	0.0016	0.0090	0.0167	0.6647	0.0883	0.0019	0.0034
SC	2.1776	.	0.0191	1.1709	0.2735	1.0046	1.8129	0.2067	0.0232	1.1709	0.5741	0.9937	0.1541	0.0156
SD	0.3266	1.3455	0.0072	0.4595	0.4230	0.7138	2.1151	0.0318	0.0175	0.7318	.	0.6625	0.1766	0.0196
SE	0.0249	0.8498	0.0017	1.3904	0.2900	0.2908	0.6647	0.0437	0.0233	0.0366	0.4230	0.3036	0.0385	0.0850
SF	0.0163	0.0638	0.0014	0.0936	0.1420	0.0661	0.2569	0.0546	0.0022	0.0732	0.1662	0.1242	0.0205	0.0708
SG	0.0085	0.0255	0.0008	0.0966	0.1088	0.1163	0.1269	0.0382	0.0090	0.3483	0.1753	0.0635	0.0144	0.0793
S+	0.0071	0.0008	0.0006	0.0205	0.0133	0.0245	0.0211	0.0080	0.0025	0.0322	0.0332	.	0.0010	0.0159
SI	0.0026	0.0008	0.0011	0.0014	0.0061	0.0069	0.0084	0.0019	0.0015	0.0004	0.0039	0.0014	0.0001	0.0011
NA	0.0053	0.0008	0.0008	0.0029	0.0755	0.0793	0.0012	0.0053	.	0.0255	0.1390	0.0196	0.0013	0.0045
NB	0.0224	0.0008	0.0069	0.0762	0.1299	1.3220	0.0181	0.0433	0.0821	0.2505	0.9367	0.3464	0.0029	0.1275
NC	0.0035	0.0035	0.0011	.	0.0224	0.9782	0.0907	2.2754	0.6298	2.7954	2.2964	0.0049	0.0445	0.0935
ND	0.0061	0.0389	0.0006	0.0410	0.0483	1.0840	0.0284	0.3050	0.6572	2.2078	2.4172	2.2083	0.1702	0.0793
NE	0.0773	0.0149	0.0008	0.0029	0.0755	2.3001	0.0594	0.1128	0.1041	0.0599	.	0.4417	0.0321	0.0793
NF	0.0061	0.1664	0.0006	0.0029	0.0846	4.7590	0.0272	0.0456	0.2191	0.0446	1.6431	0.3312	0.0462	0.0354
NG	0.0005	0.0014	0.0006	0.0059	0.3929	3.4370	0.0151	0.0674	0.0227	0.0202	0.7856	0.1794	.	0.0212
N+		0.0008	0.0006	0.0292	0.5076	0.2458	0.0181	0.0116	0.0072	0.0044	0.1632	0.0160	0.0042	0.0034
N1	0.0010	0.0008	0.0008	0.0059	0.1481	0.0343	0.0069	0.0077	0.0016	0.0004	0.0227	0.0041	0.0001	0.0017

NOTE: . MEANS MISSING DATA.

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FIGURE D-1. AVERAGE PARTICULATE CONCENTRATION FOR MONTHS WITH 0 DAYS OF SANDBLASTING
G/ m2 /MONTH

FEB AND AUG, 1980
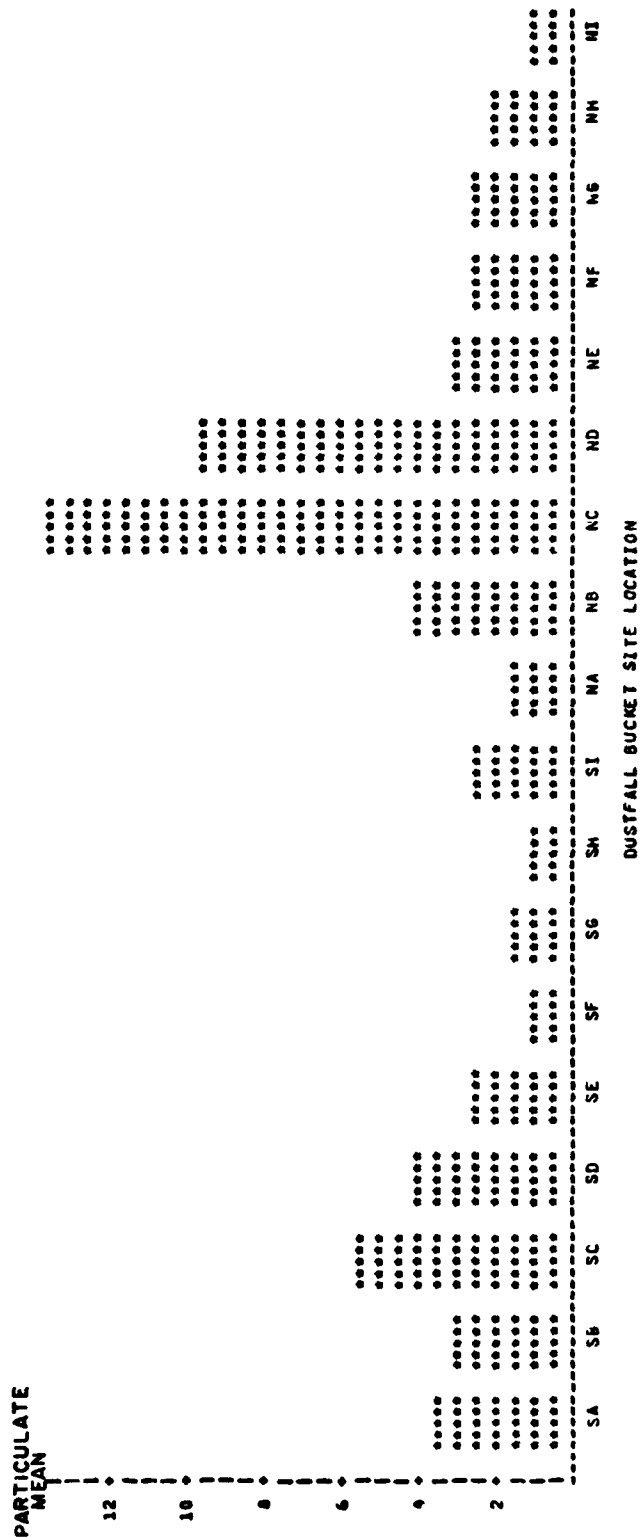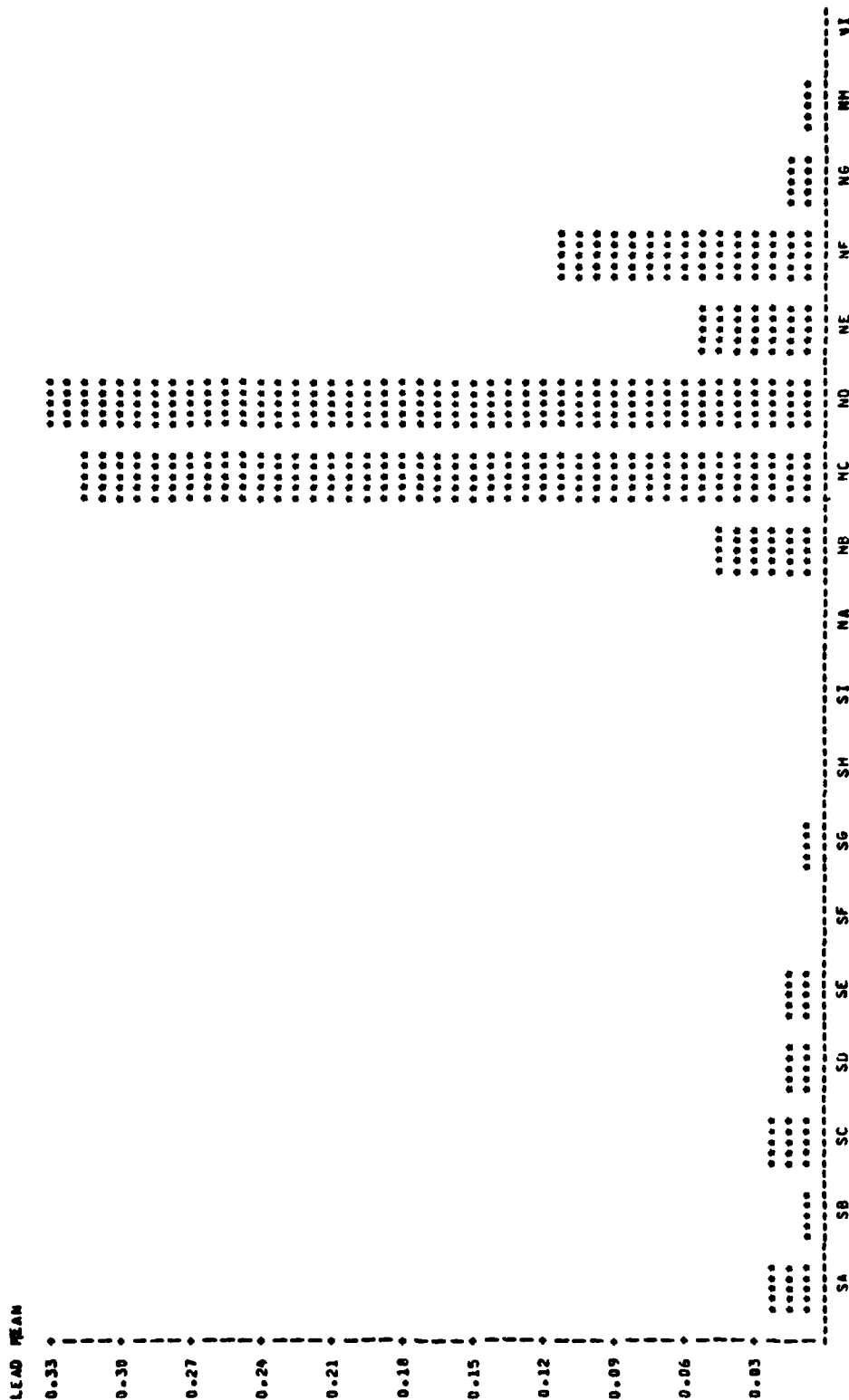
BAR CHART OF MEANS

FIGURE D-2. AVERAGE LEAD CONCENTRATION FOR MONTHS WITH 0 DAYS OF SANDBLASTING
G/m^2/MONTH

FEB AND AUG, 1980

BAR CHART OF MEANS

DUSTFALL BUCKET SITE LOCATION

FIGURE D-3. AVERAGE PARTICULATE CONCENTRATION FOR MONTHS WITH 2-9 DAYS OF SANDBLASTING
G/m2./MONTH
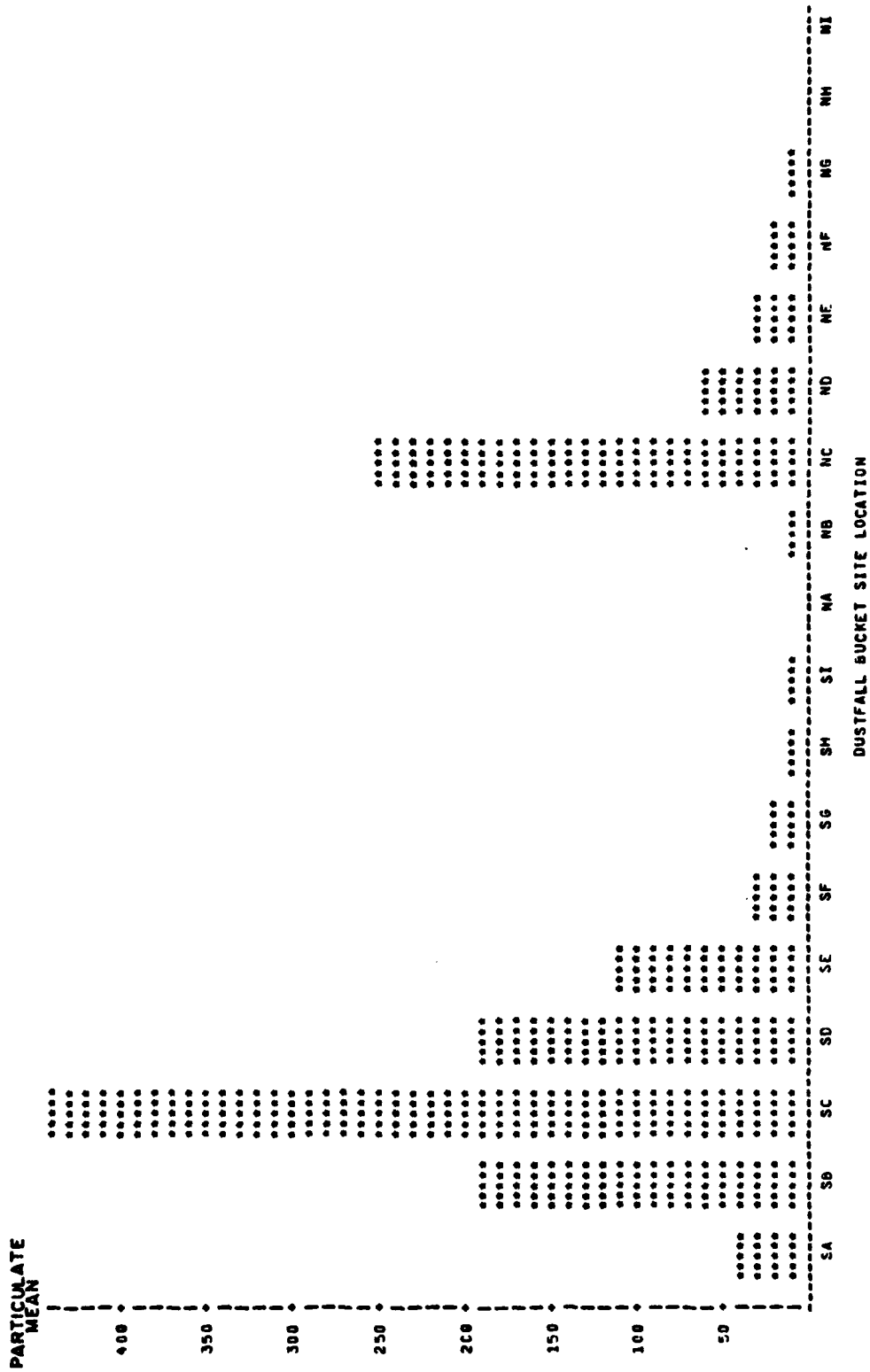
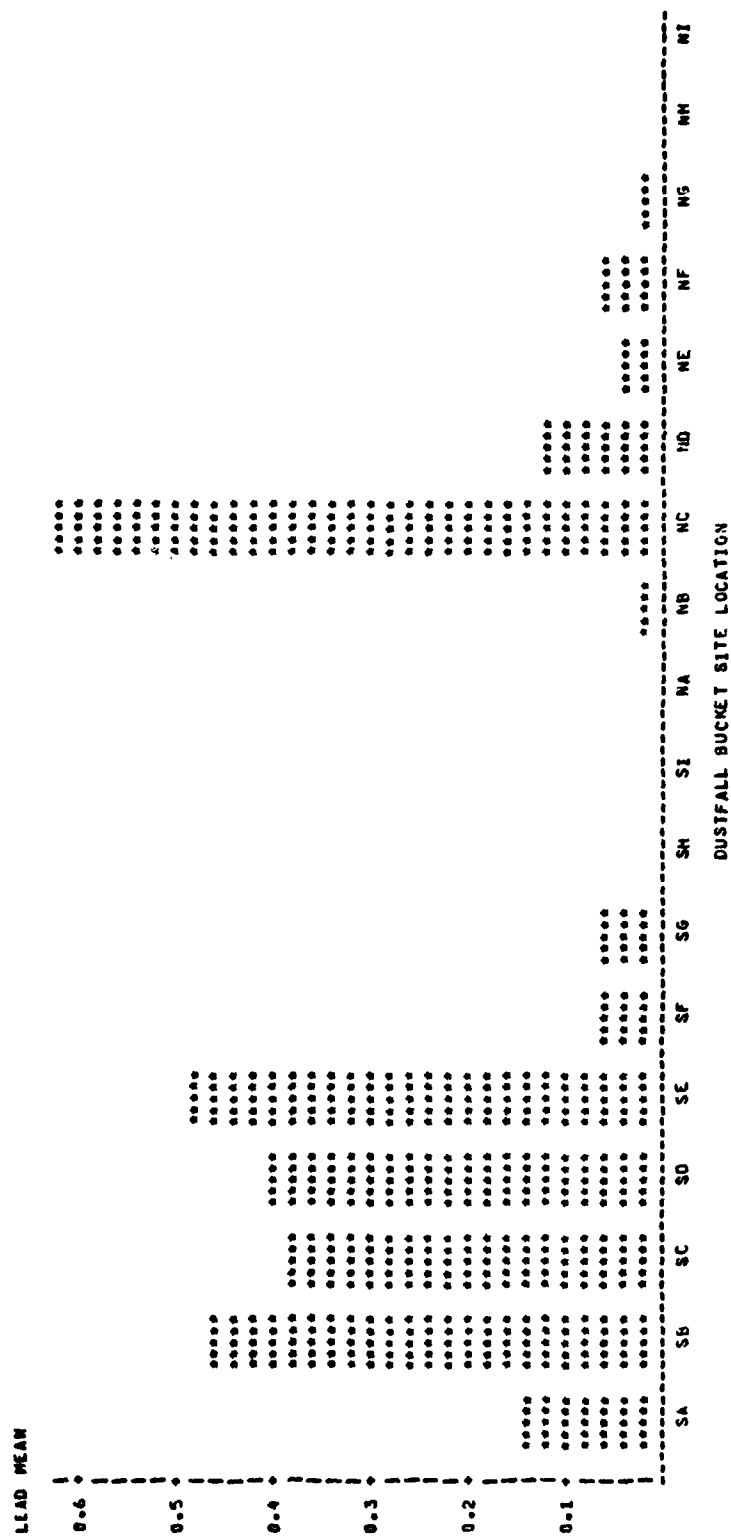JAN,MAR, JUL, DEC,1980 & JAN,1981

BAR CHART OF MEANS

PARTICULATE
MEAN

400

350

300

250

200

150

100

50

SA SB SC SD SE SF SG SH SI NA NB NC ND NE NF NG NH NI

DUSTFALL BUCKET SITE LOCATION

57

FIGURE D-4. AVERAGE LEAD CONCENTRATION FOR MONTHS WITH 2-9 DAYS OF SANDBLASTING
g/m2/MONTH

JAN, MAR, JUL, DEC, 1980 & JAN, 1981

BAR CHART OF MEANS

58

FIGURE D-5. AVERAGE PARTICULATE CONCENTRATION FOR MONTHS WITH 12-15 DAYS OF SANDBLASTING
$6/m^2/MONTH$

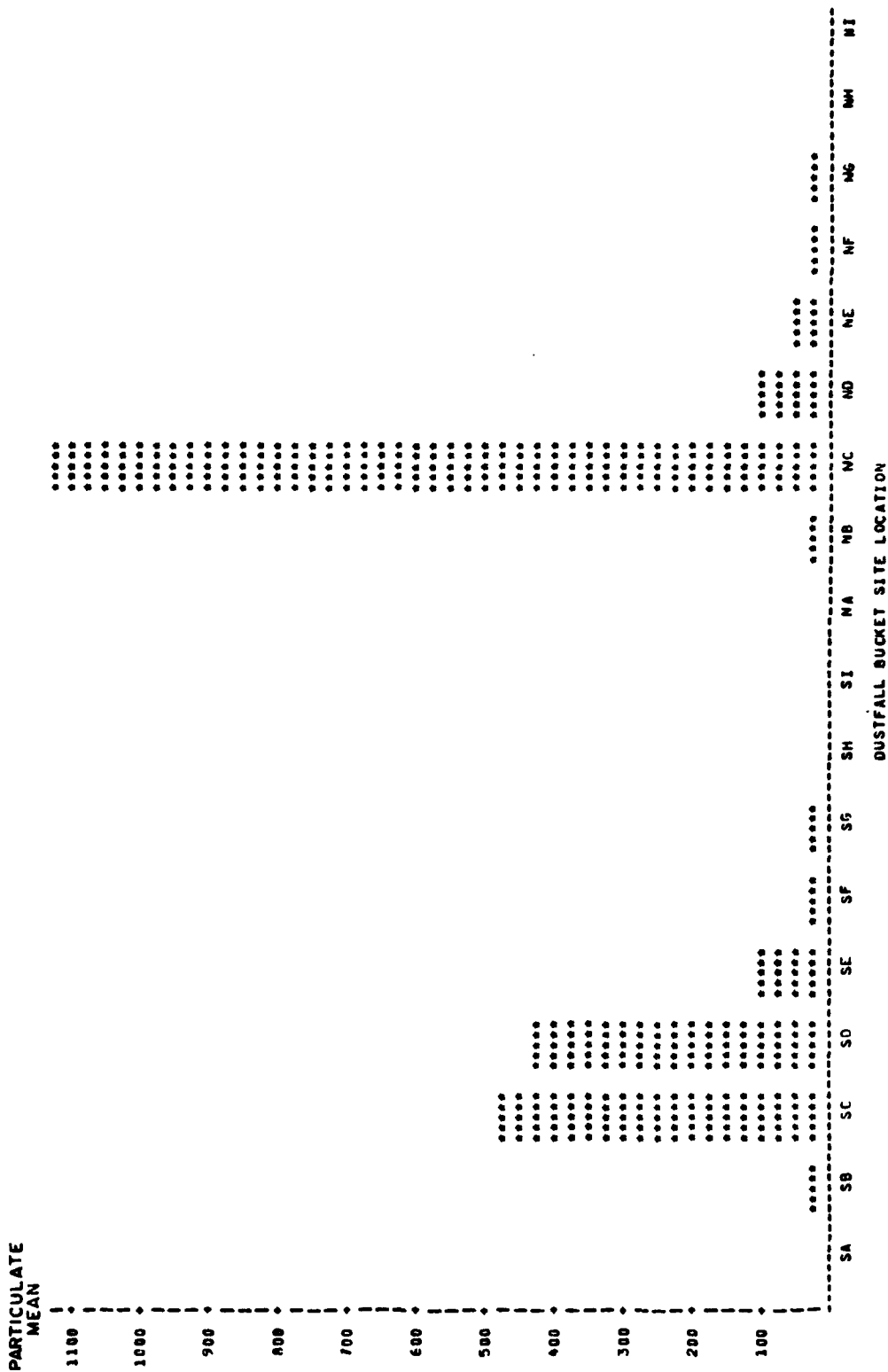DEC,1979 & JUN, SEP AND NOV, 1980

BAR CHART OF MEANS

FIGURE D-6. AVERAGE LEAD CONCENTRATION FOR MONTHS WITH 12-15 DAYS OF SANDBLASTING
$g/m^2/MONTH$

DEC,1979 & JUN, SEP & NOV,1980

BAR CHART OF MEANS

LEAD MEAN

2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3

SA SB SC SD SE SF SG SH SI NA NB NC ND NE NF NG NH NI
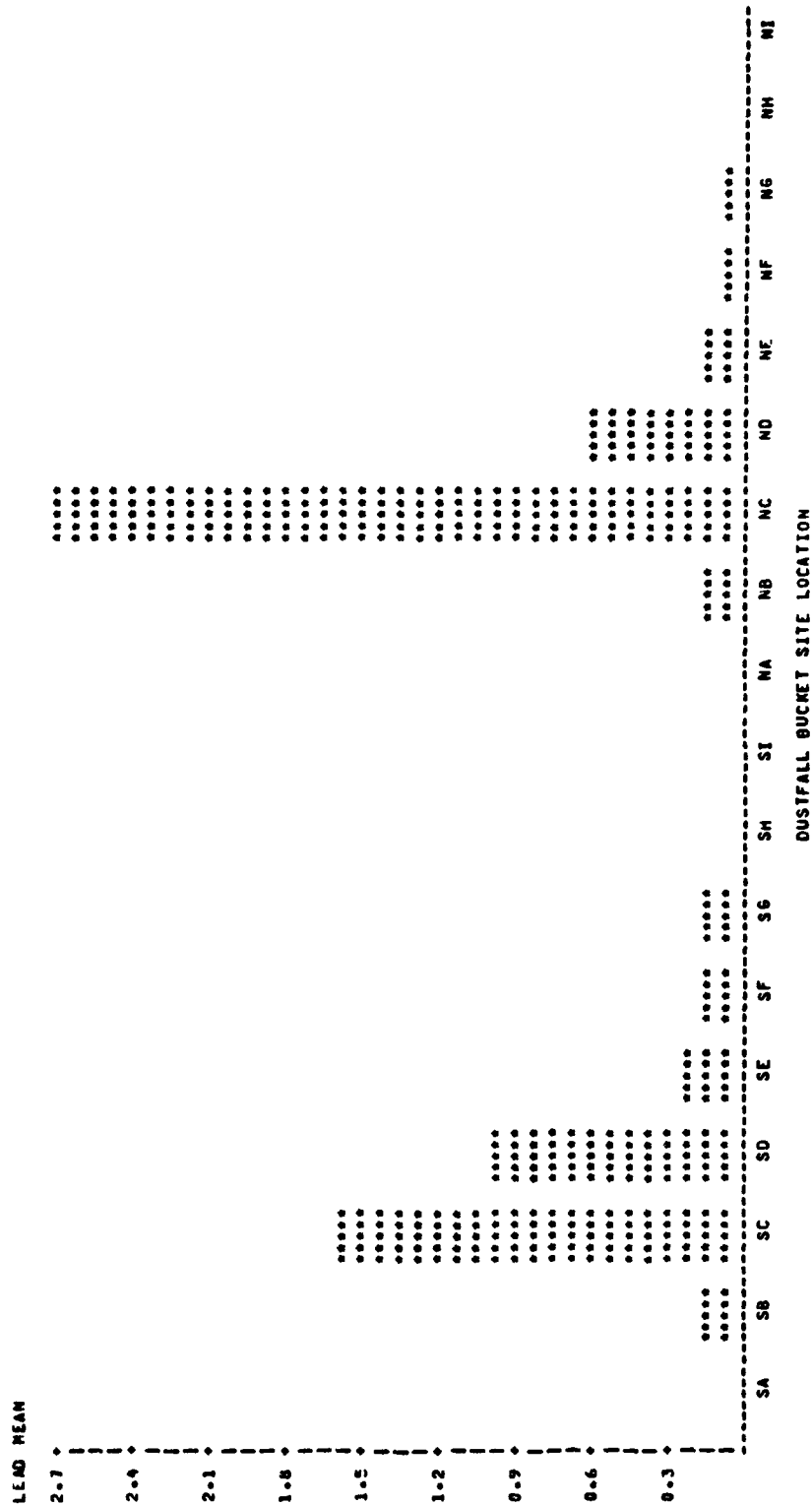
DUSTFALL BUCKET SITE LOCATION

60

FIGURE D-7. AVERAGE PARTICULATE CONCENTRATION FOR MONTHS WITH 19-23 DAYS OF SANDBLASTING
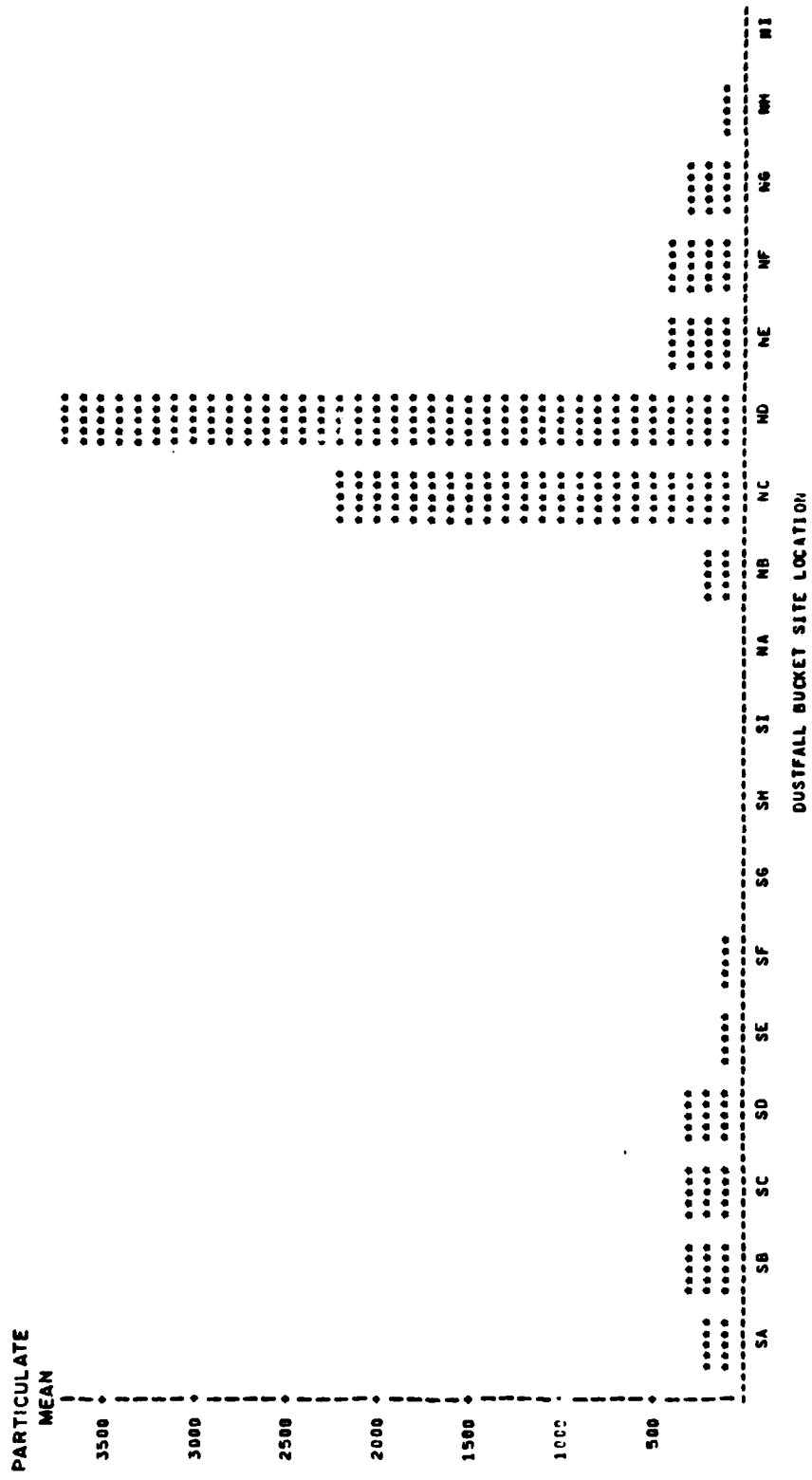
G/m^2 /MONTH

APR, MAY 8 OCT,1980

BAR CHART OF MEANS

PARTICULATE
MEAN

3500

3000

2500

2000

1500

1000

500

SA SB SC SD SE SF SG SH SI NA NB NC ND NE NF NG NH NI

DUSTFALL BUCKET SITE LOCATION

FIGURE D-8. AVERAGE LEAD CONCENTRATION FOR MONTHS WITH 19-23 DAYS OF SANDBLASTING
G/m^2/MONTH

APR, MAY AND OCT, 1980

BAR CHART OF MEANS
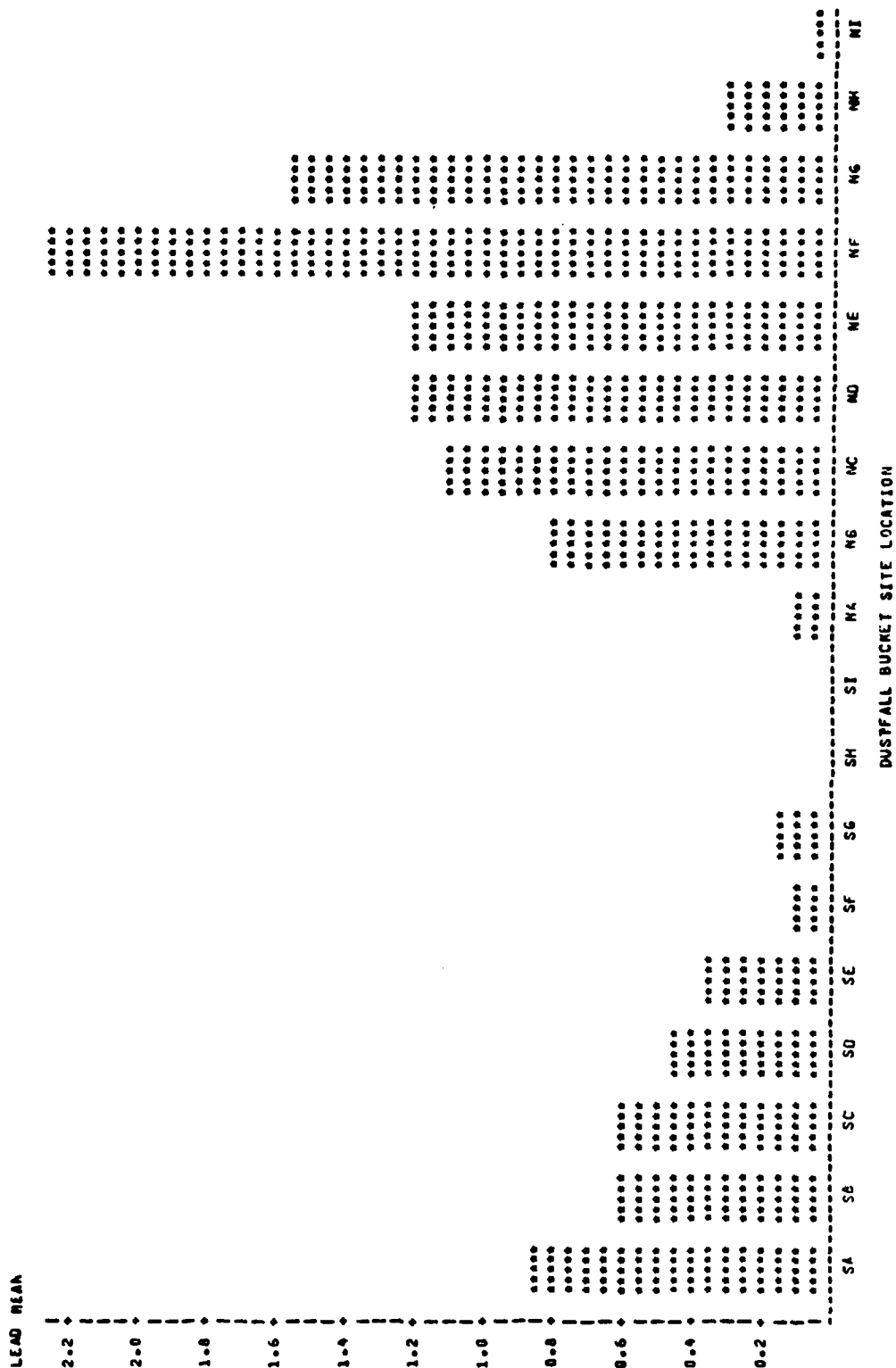
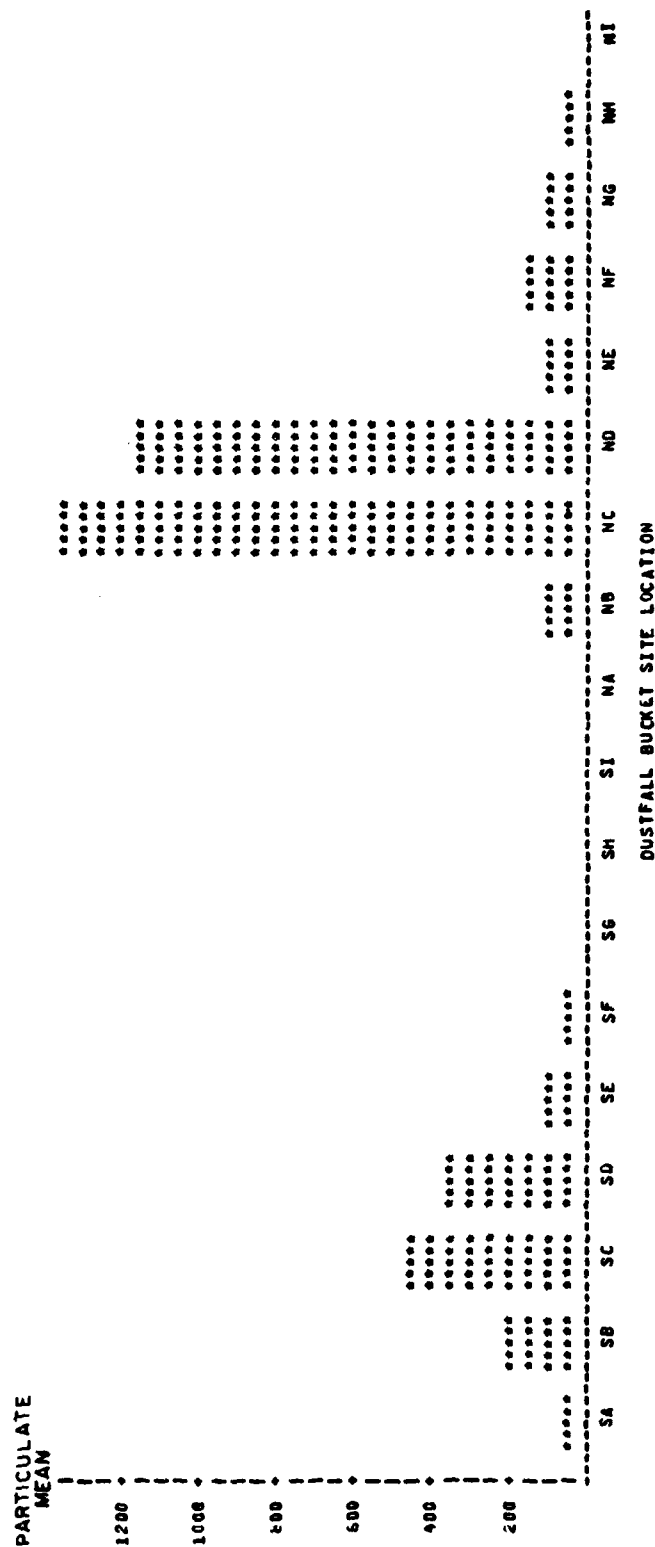DUSTFALL BUCKET SITE LOCATION

FIGURE D-9. AVERAGE PARTICULATE CONCENTRATION FOR MONTHS WITH GREATER THAN OR EQUAL TO 5 DAYS OF SANDBLASTING
g/m^2/MONTH

DEC,1979, MAR, APR, MAY, JUN, JUL, SEP, OCT, NOV,1980 & JAN,1981

BAR CHART OF MEANS

PARTICULATE
MEAN

1200

1000

800

600

400

200

SA SB SC SD SE SF SG SH SI NA NB NC ND NE NF NG NN NI

DUSTFALL BUCKET SITE LOCATION

FIGURE D-10. AVERAGE LEAD CONCENTRATION FOR MONTHS WITH GREATER THAN OR EQUAL TO 5 DAYS OF SANDBLASTING
g/ m2 /MONTH

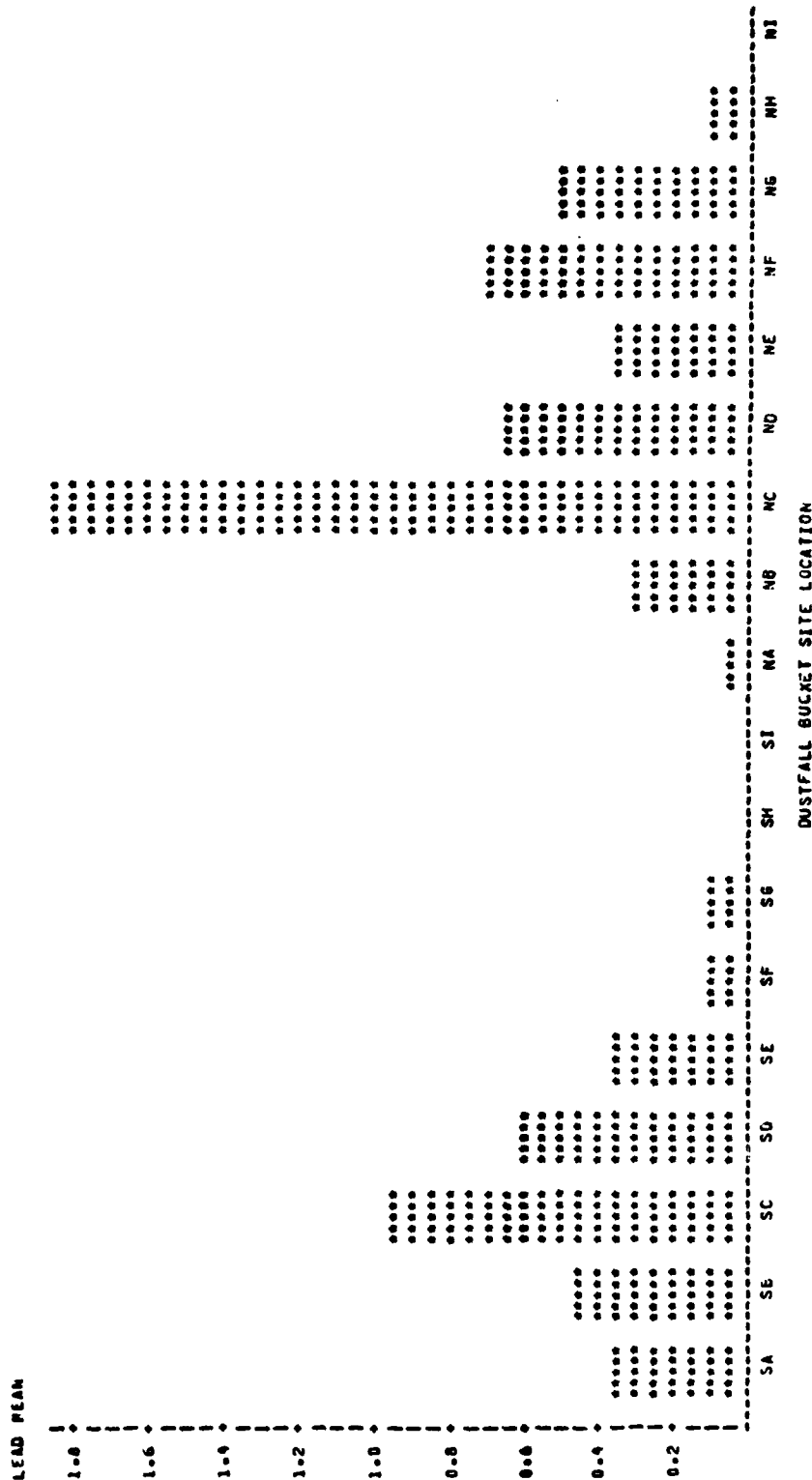DEC, 1979, MAR, APR, MAY, JUN, JUL, SEP, OCT, NOV, 1980 8 JAN, 1981

BAR CHART OF MEANS

LEAD MEAN

DUSTFALL BUCKET SITE LOCATION

END

DATE
FILMED

DTIC